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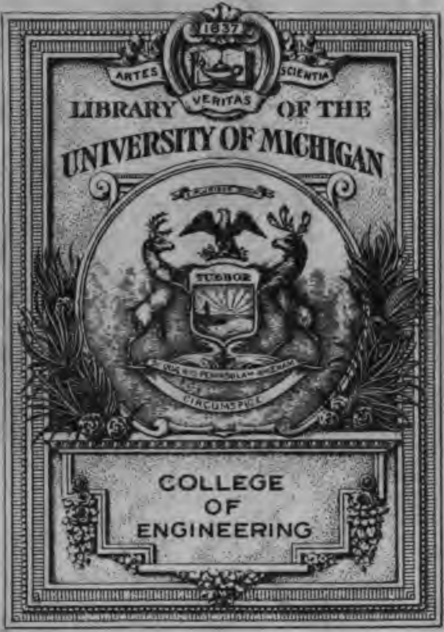

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CURVES

OF

CIVIL ENGINEERING.

THE TRANSITMAN'S POCKET COMPANION.

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THE CENTER LINE OF ENGINEERING WORKS,
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IN CONNECTION WITH
CIRCULAR, TRANSITION, AND VERTICAL CURVES.

PRICE, $2.50.

BY

ARTHUR M. HAYNES, C.E.
M. W. S. E.

37 So. Lincoln Ave., Denver, Colo.

1903.

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PREFACE.

OUR forefathers began laying out curves with 100-ft. chords, because it was a little easier to do field-work that way. In their practice the errors were not so serious as they now are, and their link chains made it more difficult to measure arcs (or anything else) than with steel tapes now used.

We have followed their example too long. This practice is responsible for countless shocking kinks in railroad curves that are covered up, whitewashed, and unknown. The average transit party does not expect to close on the P. T. closely when it had been previously set according to tables. No matter how carefully they may do their work they know there are errors in the tables that will make fudging necessary. The method is known to be inaccurate, and is made the excuse for careless work. The errors have been characterized as "inappreciable" or "negligible," but they are cumulative and increase as the square of the degree; have made much trouble, and have thrown discredit upon the profession.

One writer has furnished us a table of corrections to apply to the more important functions, but it requires interpolation, and is confusing when taken with the distractions of field-work. Another has given us voluminous tables for curve functions, for curves of integral

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degrees from 1° to 10°. That work (Butts) has been highly appreciated and ought to be in the hands of every conscientious transitman, but it is limited to the integral degrees 1° to 10°, and only demonstrates the impracticability of chord measurements. The mere idea of measuring across a chord 100 feet and *calling* it the length of the curve is revolting. The error for a 20° curve is a half of a foot. It might be excusable if it resulted in ease and simplicity in doing the work. But it results in difficulties and uncertainties. As one indication of the difficulties, there is not a curve shown on any of the filed plats of surveys for irrigation canals in Colorado. They aggregate 10,000 miles; some of them cost a half million dollars, and are fine examples of engineering, but their alinements are all attempted to be shown by straight lines and angles because *chord measuring cannot be used* on the sharp curves. The excuse for this book is to advocate *arc* measurements.

A new table of 1° Curve Functions is here given, in accordance with a new definition for "Degree of Curve," which is found in the first paragraph of the text. With measurements on the curve the table is exact for all degrees. With measurements on chords, results are as close with this table as with similar published tables. So this table is prefectly applicable on work where the errors of chord measuring is considered negligible. Logarithms and tables of natural functions are not given because they should not be used in the field. Transit work is, or should now be, in trained hands, which are supplied with such tables as those published by Professor Jones, of Cornell University, by Von Vega, or by the U. S. Geo. Survey. Special problems, too, are considered as belonging in the classroom.

The subject of transition curves is made a prominent feature. The discussion is much longer than necessary, because there has been so much literature on the subject which has to be referred to. There seems to be no other subject upon which engineers are so divided.

A section on vertical curves, too, is added, so that the ground may be better covered, as indicated in the title. While this subject applies especially to railroads, it should be applied to city street grades much more than it is. Street cars are unable to follow safely the grades that are established by the city engineer, and the unsightly appearance of sharp angles in street grades is discreditable.

The engineer's practice is of two kinds: one of location, the other of construction; one of planning, the other of executing; one dealing only with nature, the other with men, manufactured materials, and machines. This work is to assist in the first-named practice; in the location of a center or base line, both horizontally and vertically, from which all detail plans and measurements may be made. A line which will pay due respect to the inertia of moving objects and to civic æsthetics, thus to "make the dollars earn more interest." For nature abhors an angle.

A. M. HAYNES.

DENVER, COLO., October, 1903.

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CURVES OF CIVIL ENGINEERING.

CHAPTER I.

CIRCULAR CURVES.

1. ***The Degree of a Curve*** *is a term applied to circular curves in a plane and is the change of direction in degrees per one hundred feet; or, in other words, is the number of degrees in an arc of the curve one hundred feet long.*

$$\text{The radius of a curve} = \frac{5729.58}{\text{degree}}.$$

$$\text{The radius of a } 1^\circ \text{ curve} = \frac{18000}{\pi} = 5729.57795.$$

2. Circular curves are projected on maps by means of their radii with the compass. On the ground it is generally found necessary to make use of the geometrical theorem that an arc subtends an angle on the circumference equal to one half the angle at the center subtended by the same arc. A transit is placed on the curve (or circumference) and the curve is located in 100-ft. arcs by turning angles for each arc equal to one half the degree of the curve. The work can be commenced and carried on at an unknown distance from the transit, but it is generally required to begin at the transit so that it may conform with a previously located tangent.

When there is special reason for doing so, arcs of less than 100 ft. can be located by deflecting angles proportional to the length of arc measured.

It is bad practice to try to locate points on a curve more than 60° from the transit, because one end of the tape line is held on the curve, while the other end describes an arc with the tape as a radius, and the new point being fixed on the curve, is at the intersection of this arc with the line of colimation from the transit. This angle of intersection is 0° at 180° from transit, and is too acute for accuracy beyond 60° from transit.

It is impracticable to have the measuring line on the curve. So it is placed on the chord in a straight line, but the end is held back, distances given in Table I, so that the result is the same as though actually measured on the arc.

3. A curve of uniform degree in one direction is a **Simple Curve.** Two or more curves in the same direction connected, and with a common tangent at point of connection, is a **Compound Curve.** If such curves are in opposite directions they form a **Reverse Curve.** A **Tangent** to a curve is a straight line which intersects it but does not cross.

CHAPTER II.

ALINEMENT OF ENGINEERING WORKS.

4. Engineering works, such as railways, canals, boulevards, dams, tramways, etc., are surveyed and staked out with a line of stakes one hundred feet apart and numbered consecutively, beginning with station 0 at one end of the work. Such points are called stations; when it is necessary to have points between two stations the distance is measured from the last station and this distance is called a plus. The

stake is marked the last station + the distance from it in feet and tenths thereof.

5. At station 0 and at other points along the line where it is necessary to set up the transit, a hub is driven flush with the ground and a tack put in the hub to mark the exact point. The stake is driven in the ground vertically one foot left, or if to be on a curve, on the convex side of the curve and facing the hub. Such points are called transit points, and the stakes to the side are witness stakes, which have markings on the back side as follows:

6. P. O. T., for a point on tangent.
P. R. C., for a point of reverse curve.
P. R. S., for a point of reverse spiral.
P. C. C., for a point of compound curve.
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P. C., for a point at beginning of a circular curve.
P. T., for a point at beginning of a tangent.
P. I., for a point at intersection of tangents.

Sometimes the degree of the curves and the whole alinement is indicated on the stakes from which any one can take notes and plat the whole line. It is not advisable to give to the public such information, and friends of the enterprise do not need transit notes in that form. Until late years such alinements have consisted only of circular curves and tangents. But the refinements of railway operation now demand that rapidly moving heavy objects shall not pass directly from tangents to sharp circular curves and back again but must have their direction changed gradually over transition curves. The transition curve has had a long, hard birth, but it is now so easy to handle that it may be introduced into the alinement of canals, roads, streets, and where the only gain is in appearance.

CHAPTER III.

LINEAR MEASUREMENTS.

7. All measurements should be made with a 100-ft. steel tape, eleven steel marking pins, a hand level, and a plumb bob. The work is done by a head tapeman, rear tapeman, stake-marker, and axman, all under the direction of the head tapeman, who receives his instructions from the transitman or assistant locating engineer. The 0 end of the tape is kept behind and if plusses are to be taken the stake-marker drags the tape ahead until the 0 end is at the last station. Then the head tapeman reads the plus and sets the point.

8. The rear tapeman should not be allowed to hold his 0 end of the tape at any plus stakes or hubs, but should always remain at the last station point until the next one ahead is set. This obviates the uncertainty of mental calculations on the part of tapemen. The tapemen do not handle stakes but fix the points in the ground with the steel pins. The head tapeman carries a range pole by which the transitman puts him on line when the steel pins are not visible. The stake-marker drops a properly marked stake at each pin. The tapemen check these markings by calling out the numbers found on these stakes when they make the measurement. The axman follows, pulls up the pins and drives the stakes in their places.

The tapemen should work as close to the ground as possible and thus avoid sags in the tape, wind, swinging plumb bobs, irregular tension, mistaken horizon and loss of time in trying to locate points of plumb bobs. A tapeman who dislikes to stoop is unreliable. Sometimes, in grass or brushy land where the middle of the tape is supported, it is best to work from the tops of stakes if there be soil to hold them firmly. Even plumb bobs may sometimes be used, and all work done in the air to avoid cutting brush. But work in the air and plumbing down by either tapemen or transitmen should be avoided as much as possible.

9. When on a slope the rear tapeman "lets out" the tape enough to give horizontal measurements and when measuring on a chord of a curve "pulls in" the tape enough to give arc measurements. The amounts to give or take are shown in Table I and Diagram IV. The rise or fall per 100 is noted with the hand level; one tapeman uses the other as a level rod. They soon learn where the graduations are on each man, though he be not marked. The correction is inappreciable for gentle slopes. When the slope becomes more than 6 per hundred it becomes expedient to "break chain," using not more than 50 ft. of the tape at one time, holding one end up to horizontal and plumbing down. But the previous remarks regarding plusses should be borne in mind and the rear end of the tape kept at the last station.

Table I is essentially the rear tapeman's table. No one else has any use for it except to know that the tapemen use it properly.

10. The 0 end of the tape should extend 0.5 beyond the 0 mark and the back of the tape graduated for slope and chord measuring. Manufacturers are prepared to furnish them, giving the graduations back from the 0 mark for the different slopes and ahead from the 0 mark for each degree of curve. The movable clamped index point (Lallie's patent) should be used on the tape to insure against the rear tapeman's forgetfulness when on curves. If errors are thus made by his forgetfulness it would be no more serious than if made by the engineer's design, as has been done for a century.

CHAPTER IV.

GENERAL DISCIPLINE.

11. Each man should attend *strictly* to his own duties. Willingness to help others is an undesirable qualification here. Few words should be the rule, and distracting talk prohibited. When a signal or instruction is given it should *always* receive a response by motion of arms or saying "All right" when understood. Rank goes with salary, and no two should have the same rank, so that it will be well understood who controls movements when working in detachments. They should work as one man. Shouting indicates lack of skill.

12. Orders should be few as possible and in the form of casual remarks or questions until it appears that an assistant does not try to please. Then imperative orders become necessary; but they should always indicate a condition that cannot long endure. Keep watch for the one man who often disaffects the whole party. No one man should be allowed, in peace, to be habitually the last at breakfast or at work. The men should be required to bunk together, and their baggage limited to simple necessities.

Each assistant should feel sure of exact justice and impartiality; that his comfort and welfare are given careful consideration. If called upon to suffer hardship and exposure, he is not to reason why, but feel that it is unavoidable. Results are obtained by thought and management, not by long hours and labor alone. The day's work should be planned the evening before, and started immediately after breakfast without any questions or confusion. Strict discipline is for the good of all, and should be distasteful to none.

CHAPTER V.

ANGULAR MEASUREMENTS.

13. The transitman should be relieved from the discipline and management of the party as far as possible, so that he can give his undivided attention to the mathematics of his work and the adjustments of his instrument. A close record should be kept of the azimuth (or corrected courses) of all tangents. If they are true all his work must be correct unless there be balancing errors, which is *very* improbable.

He should commence with a true meridian, determined astronomically. Then, as he progresses with his survey, he can check in the same way as often as desired. The magnetic needle gives a rough check and a very useful one because it is so easily and often applied. He should be given every opportunity to make complete ties with lines that may have been run through the country before. If there be none, it may be expedient to run one (without chaining), simply for the purpose of checking azimuth. Angles are measured to the nearest minute, so there is a *possible* allowable error in azimuth equal to as many half minutes as there are transit points, but such a possibility should not be considered. It is the grossest carelessness to allow the azimuth to go unchecked.

14. A complete tie is illustrated in the sample transit notes, top of page 37. The transitman should be given vistas close to the ground when setting transit points, so that he will not have to rely upon the head tapeman's skill in plumbing down. The rear flag should always be on the point last occupied by the transit. Otherwise the angles will depend upon the work of the tapemen. He should not be required to locate short spirals and

should never be forced into short sights. If transit hubs come near together on the line he should be given time to fix sights upon distant objects, even if men have to be sent to set such sights.

If chord measurements are used plusses for transit points should be avoided as much as possible. Plusses on curves cause errors, unless Table I is used. Such errors become magnified if the back flag is not always on the point last used by the transit. The transitman should be given large discretion in everything that pertains to the accuracy of the transit work. Detailed instructions relieve him of responsibility. The chief is apt to be rusty and behind the times in transit work. He may advise but should not crowd his ideas or assistants upon the transitman. He only cares to have the azimuth check first, and speed afterwards.

CHAPTER VI.

A TRUE MERIDIAN.

15. Is generally best obtained by means of the eastern or western elongation of Polaris. This happens twice a day at times in this country when it is not inconvenient to make the observation after dark during the seasons of field-work. The elongation occurs when the handle of the "Great Dipper" is due east or west of Polaris. The exact time can be determined by watching the star until it apparently ceases to move and changes its direction. The true pole is then between Polaris and the "Great Dipper," the angle from Polaris being given in Table VIII. The cross hairs may be illuminated by a common candle held near the object glass. The transit holds the line until daylight, when the result of the observation is secured. The vertical angle to Polaris gives the latitude to be used in the table.

CHAPTER VII.

FIELD-WORK.

16. To locate a curve on the ground (either with or without spirals) connecting two tangents, the tangents should be run out to an intersection if practicable. It is not necessary, but it promotes accuracy to work from the point of intersection. The P. I. is also useful as a permanent monument of the survey since it is generally out of the way of grading operations which destroy the rest of the line.

17. The shortest line from the P. I. to the curve is the **External Secant.** From the P. I. to the ends of the curve is the **Tangent Distance,** and between the ends of the curve is the **Long Chord.** These three functions of the curve are found in Table IX.

Even if the P. I. is not located on the ground this tangent distance must be shown in the field-notes before the platting is done. When the P. I. is located (the station stakes being set up to the P. I.), the transitman measures the whole angle. From Table IX he takes the tangent distance corresponding to this whole angle. If he is to put in transition curves he adds the amount shown in the Table IX for the spiral selected. This total he divides by the degree of curve to be used which gives his tangent distance. He then instructs the head tapeman to measure this distance along the unmeasured tangent ahead and set the P. T. While the party is doing this and returning, he checks and completes his calculations for the curve. He subtracts the tangent distance from the station of the P. I., which gives him the station of the P. C. or P. S. This

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that is, inversely as the degree. This property makes it possible to tabulate all the dimensions of the combined curves and of the individual spirals for 1° curves, and all the calculation that is necessary is division by the degree of curve.

Table IX not only gives the usual functions for a 1° curve, but gives the same functions for the 1° curve, combined with three different types of spirals—a No. 5, No. 9, and No. 14—which is believed to be all that are ever needed in railway practice. They have unreasonable dimensions for a 1° curve, but they are not expected to be used with a 1° curve. When used with sharp curves their dimensions, being divided by the degree of curves, become manageable. Chords are 100 ft. long for a 1° curve, but only 10 ft. long for a 10° curve, 25 ft. long for a 4° curve, etc. The No. 5 consists of 5 chords, No. 9 consists of 9 chords, No. 14 consists of 14 chords, etc. They are always located by the same deflection angles given on page 22.

No. 5 is suitable for the easy curvature of "prairie roads," and No. 14 is designed for the sharp curvature of mountain lines. These curves are "cubic parabolas practically," with a maximum curvature of 1° when 100-ft. chords are used, and in all cases equal the curvature of the main or central curve. By reference to Table I it will be seen that the difference between lengths of the chords and curves are truly negligible on account of the short chords. Since there are no finite arcs, chord measurements are used in this connection. The No. 5 is "Searles spiral," and the No. 9 is used on the Union Pacific Railway after Holbrook's plan. They have the deflections figured so that the spiral can be located from each chord-point. But it is seldom convenient and never necessary to set the transit on the middle portion of the spiral. It should not tax the ingenuity of the transitman much to get around all obstacles by means of the dimensions given on page 23, though the general deflection table, page 25, will accommodate the most exacting.

21. *Selection.*—There is no necessity for a great variety of spirals. On a given line of railroad the variety of circular curves is generally small. The maximum curves predominate, because the locating engineer can generally save distance and total curvature by using the sharpest curves allowable. On tortuous mountain lines often 75% of the curves are of maximum degree. So if a spiral be selected that is suitable for the maximum degree of curvature, it may be generally considered suitable for the whole line. It may be unnecessarily long for some of the easier curvature, but the objection (if it be an objection) is not serious nor frequent, and the advantage of a system is great.

Theoretically the longer the spiral the sharper the central curve has to be. But since the longer spirals are in connection with the easier curves that objection is void. The theory that the length of "run off" should vary as the degree of curve is false, because it rests on the assumption that train velocity is as high on sharp as on easy curves. A 60-mile velocity requires twice the superelevation and length of "run off" as a 42-mile velocity, per Diagram III. So, when variation in speed is considered, the old "run off" is often longer on the easier curvature.

If a superelevation of more than 7 inches be prohibited (which is customary) and if it be undesirable to have an excessive load on the outer rail, it is undesirable to have a velocity

of more than 30 miles per hour on a 12° curve.
" " " 40 " " " " 6° 30′ "
" " " 50 " " " " 4° "
" " " 60 " " " " 3° "
" " " 80 " " " " 2° "

This is apparent from Diagram III and probably gives higher velocities than is practiced, or than is safe on ordinary track.

A 1° curve is too easy anywhere. A 1½° curve is preferable and needs no easement, and may generally be made to take the place of a 2°.

The No. 5 spiral may be used on curves of less than 5°, the No. 9 on curves from 4° to 9°, the No. 14 on curves from 7° to 14°, making spirals between 100 and 200 ft. long.

22. DEFLECTION ANGLES.

No. 5 Spiral is located by the following deflection angles:

From tangent end 0° 05′, 0° 12½′, 0° 23⅓′, 0° 37½′, 0° 55′
" curve " 0° 25′, 0° 47½′, 1° 6⅔′, 1° 22½′, 1° 35′

Whole angle, 2° 30′

No. 9 Spiral is located by the following deflection angles:

From tangent end 3′, 7½′, 14′, 22½′, 33′, 45½′,
1° 0′, 1° 16½′, 1° 35′
From curve end 27′, 52½′, 1° 16′, 1° 37½′,
1° 57′, 2° 14½′, 2° 30′, 2° 43½′. 2° 55′

Whole angle, 4° 30′

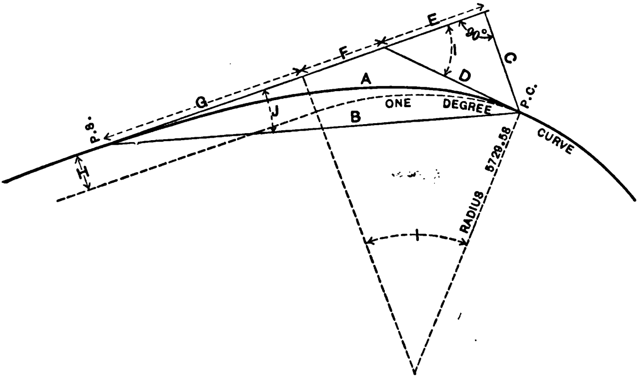
No. 14 Spiral is located by the following deflection angles:

From tangent end 2′, 5′, 9⅓′, 15′, 22′, 30⅓′, 40′, 51′, 1° 3⅓′, 1° 17′, 1° 32′, 1° 48⅓′, 2° 6′, 2° 25′.

From curve end 28′, 55′, 1° 20⅔′, 1° 45′, 2° 08′, 2° 29⅔′, 2° 50′, 3° 09′, 3° 26⅔′, 3° 43′, 3° 58′, 4° 11⅔′, 4° 35′.

23. ELEMENTS OF INDIVIDUAL SPIRALS FOR A 1° CURVE.

For elements of spirals for other curves divide by the degree.



	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*
									° ′	° ′
No. 5 spiral...	500	499.95	8.00	183.3	183.2	66.7	250.0	2.55	2 30	0 55
No. 9 spiral...	900	899.74	24.86	316.9	315.9	133.6	449.9	7.20	4 30	1 35
No. 14 spiral..	1400	1399.1	58.99	484.0	480.4	218.34	699.1	16.3	7 00	2 25

Ordinates from tangent to each 100 ft. from P. S:

No. 5 Spiral—0.14, 0.73, 2.00, 4.40, 8.00.

No. 9 " — .09, .4, 1.2, 2.6, 4.8, 7.9, 12.2, 17.8, 2.48.

No. 14 " — .06, .29, .81, 1.74, 3.20, 5.29, 8.14. 11.86, 16.57, 22.38, 29.41, 37.78, 47.59, 58.99.

24. Space is left in the table for inserting the elements of other spirals should the three given fail to meet all requirements. The street railway people are not fully provided for, because their needs are not understood and they are wedded to a system of ordinates. But with arc measurements they can lay out their

sharp curves in the same way as do other engineers, as they have not been able to do before. So this article will be continued for the benefit of those who wish to analyze and fix the tables for a special use, to accord with individual tastes and opinions; about "run off" for instance, which has been a live subject and may be kept alive indefinitely.

25. THE GENERAL POLAR EQUATION

of this curve is

$$\theta = 2a\left(\frac{r^2}{6} + \frac{r}{4} + \frac{1}{12}\right), \text{ where}$$

a = first deflection angle from tangent (for first chord),
θ = any other deflection angle from tangent to chord point,
r = number of chords distant (corresponds to radius vector).

The second differential coefficient of this equation is $\frac{2a}{3}$, by which the first column in the table of deflections is readily obtained.

Let N = *the number of a spiral*, which corresponds to the number of 100-ft. chords that are necessary to make a maximum curvature of 1° at the end, then

$$\text{Whole angle of spiral} - \frac{N^\circ}{2}$$

$$N = \frac{30}{a} - 1$$

$$a = \frac{30}{N+1}$$

$$J = 10N' + 5'$$
$$H = 100\,N \sin\,(2\tfrac{1}{2}N' + 5)'.$$

Spirals increase tangent distances $G+H$ tan ½ whole angle.

Spirals increase external secants $\frac{H}{\cos \frac{1}{2} \text{ whole angle}}$.

Thus figures relating to spirals are inserted in Table IX

26. GENERAL DEFLECTION TABLE.

(A table of coefficients.)

			Different Positions of Transit.									
			1	2	3	4	5	6	7	8	9	10
Chord Points.	P. S.	⊙	1	3½	7⅓	12½	19	26⅝	36	46½	58⅓	71½
	1	1	⊙	2	5½	10⅓	16½	24	32⅝	43	54½	67⅓
	2	2½	2	⊙	3	7½	13⅓	20½	29	38⅝	50	62½
	3	4⅔	4½	3	⊙	4	9½	16⅓	24½	34	44⅝	57
	4	7½	7⅔	6½	4	⊙	5	11½	19⅓	28½	39	50⅝
	5	11	11½	10⅔	8½	5	⊙	6	13½	22⅓	32½	44
	6	15⅙	16	15½	13⅔	10½	6	⊙	7	15½	25⅓	36½
	7	20	21⅙	21	19½	16⅔	12½	7	⊙	8	17½	28⅓
	8	25½	27	27⅙	26	23½	19⅔	14½	8	⊙	9	19½
	9	31⅔	33½	34	33⅙	31	27½	22⅔	16½	9	⊙	10
	10	38½	40⅔	41½	41	39⅙	36	31½	25⅔	18½	10	⊙

This is an actual table for a No. 29 spiral where $a=1$.

To use the table for any spiral multiply all the tabular quantities by a; or $\frac{30}{N+1}$.

That is, for a No. 5 spiral multiply the tabular quantities by 5′, for a No. 9 spiral by 3′, for a No. 14 by 2′, etc.

The different positions of transit are shown thus ⊙, from which read up for deflections toward the tangent and down for deflections toward the curve. This table is easily extended by use of the constant differences which exist in the diagonal rows of figures parallel with ⊙. These constant differences equal the number of rows from ⊙.

Other interesting properties of this curve are ably presented by Torrance, Vial and Fulton in Vol. VII, No. 2 Journal of the Western Society of Engineers.

CHAPTER IX.

PLATTING.

27. The draftsman should plat the line under the direction of the transitman. The transitman should not lay his more or less perfect notes upon the draftsman's table and feel that he is through with them. The draftsman should not handle the transit notes, but they should be read to him, leaving him free to watch his points and handle his tools, and allowing the transitman to keep his books until full, and making the notes continuous. With proper system a day's work can thus be platted in half an hour. The chief of the party has much to do with the draftsman directly, and he should be careful that the draftsman does not get a wrong idea of his position, that he may not think that instrument-men are under his care, or that he is independent of them. When lines do not come together on paper as they do on the ground it is the *transitman's* duty to find the error with the draftsman's assistance, and himself explain to the chief of the party. Much confusion is caused by separating the field-work and drafting both in camp and on maintenance work. Draftsmen and fieldmen too often make trouble for each other and the company.

The transitman should prepare a schedule from his notes showing the courses and distances of all tangents from P. I. to P. I., and on long chords of compound curves. From this sheet the draftsman can plat alone if the transitman is pressed for time. He first draws a light, straight line through the center of the roll of detail paper. A course is given to this line corresponding to the general direction of the survey.

From this line all courses are taken by means of the protractor and transferred with the triangle and straightedge or parallel rule to any part of the map desired.

28. When the lines are all platted as described in the schedule then the tangents are scaled off from the P. I.'s, and the centers of curves located. When transition curves are used it is more convenient to draw the secant lines and to locate the centers of curves on them by scaling first from the P. I. the external secant to the curve, then the radius to the center required. Then draw the circular curves with the compass and the transition curves with the spiral rule. Write the station and plus for each P. C., P. S., and P. T. *in* the radial lines, and the angles and degrees between the radial lines. Then, with the spring dividers and scale, locate every even tenth station from 0. This is done only for a check, and need not be inked in if there be crowding of figures. If the work is done in the order named any possible error in platting or calculating will be detected. The transitman may then leave the work to the draftsman and topographer. The line should be inked in with vermilion water color, but the station numbers should be left in pencil so their position may be shifted if they be found to interfere with topography notes. Letters and figures of all kinds should be made to read from the southerly side of the plat. A simple record of the spiral angle gives complete information regarding the spiral. The number might be given, but that would be twice the whole angle of the spiral in degrees.

29. As has been intimated, when compound curves with spirals are encountered, the long chords of curves are platted instead of the tangents. Because tables cannot then be used in determining tangent distances, so it becomes a special problem quite complicated. First the chord of the spiral is platted, then of the first cir-

cular curve, then of the next circular curve or curves, and finally of the last transition curve.

This method of platting also has to be used if the locating engineer thinks there should be different kinds of spirals at the two ends of a simple curve, or if a spiral has to be located between two parts of a compound curve. These complications ought to be avoided, and can be with a little ingenuity. Compound curves cannot be avoided, but connecting curves of great difference in degree, necessitating a spiral, can be avoided by putting in one or two additional P. C. C.'s. For those who disagree and have time for the confusing calculations use the No. 9 or No. 14 spirals. The chord-lengths are made to correspond to the sharper curve; that is, 100 divided by the degree. A part is taken off from the tangent end of the spiral proportional to the smaller degree. That is if a 3° is connected with a 9° curve three chords will be taken off the tangent end of the No. 9 spiral. Here the complete deflection table is necessary to turn deflections from the third-chord point. The field-work is simple. The computations for platting are by main strength and awkwardness of latitudes and departures.

Convenience of platting should be considered in all field-work. A large percentage of surveys are wasted because they cannot be easily, intelligently platted.

CHAPTER X.

TURNOUT CURVES.

30. An ordinary standard-gage turnout from tangent first makes an angle of about 2°, then runs straight 16 ft. along the split rail, then there should be a true circular curve to the wing of the frog, then a tangent

for the full length of the frog, about 13 ft., and on to clearance or to the next frog if it be a cross-over. The lines of a frog are straight and rigid. This alinement is further complicated by widening the gage on the curve and at the point of frog.

So it is impractical to do this work with the transit. The lead rail is located by ordinates from the main-line rail. The whole angle of the lead-rail curve equals the angle of the frog, minus the angle of the split rail. The length of the curve depends upon the dimensions of the frog, the split rail, and the pattern of rail. It is quite simple to design a standard plan when all these data are known. There would be only two or three such plans for a large railroad system. Crotch frogs are generally prohibited. If used they break up the lead into two curves with a tangent over the frog. Turnouts from curves are avoided if possible, but if unavoidable the standard plan may be used the same as if on tangent. The transit work should begin at the P. I. where the tangent passing the frog intersects the center of main line. There turn the frog angle, run past the frog, after which curves may be started as desired. Tables cannot be used except for approximate work. There are no practicable special problems. They are all spoiled by the frog tangents, if not by the split rails.

31. The transitman should not be intimidated by the mass of figures and formulas that are sometimes used to illuminate this subject. The problems are all quite simple and not different from those encountered elsewhere in curve location. For example, to stake out the grading the turnout curves may be considered as having a whole angle equal to the frog angle, and an external secant equal to ½ gage. With these data enter Table IX and find the degree and length of curve as close to the truth as can be obtained by any special turnout tables, or formulas, but only close enough to use

in grading. Yard maps cannot be made until after track laying, since rail-joints fix the location of switches.

Ill-founded theories] and formulas regarding turnouts has done much to take track-work out of the hands of engineers. It has been one cause of the vexatious reference to the difference between theory and practice. There would be no difference if the engineer was left to figure out his own special problems and understand the foundation of all theories. Rules and tables are dangerous in the hands of those unable to reproduce them independently.

CHAPTER XI.

VERTICAL CURVES.

32. Vertical curves are laid out by vertical ordinates from a horizontal line with the level. They are usually very flat on railroads in comparison with horizontal curves. The sharpest vertical curve allowed on at least two prominent railroad main lines has a radius of 114,000 ft. This accounts for the simple formulas and definitions in this connection.

The curvature of vertical curves is designated by numbers in place of degrees. ***The Number of a Curve*** is its change in its rate of grade, expressed in hundredths of a foot, per hundred feet. For example, a No. 7 curve changes its rate of grade .07 each successive 100 ft. This .07 corresponds to the chord deflection in horizontal curves. If the grade be assumed to run on the 100-ft. chords of the curve the rate of grade on the first chord from tangent will be changed in hundredths, only one half the number of the curve, for the same reason that the tangent deflections are half of chord deflections. But for all succeeding chords the rate of grade changes as many hundredths as the number of the curve.

The Whole Angle is designated by tenths of a foot per hundred in place of degrees. For example, if a -0.8 grade intersects a $+0.9$ grade the angle formed will be 17 tenths.

If A = whole angle, N = number, S = external secant in tenths, and L = length of curve in stations, then

$$N=\frac{10A}{L} \text{ and } S=\tfrac{1}{8}AL.$$

Approximate radius in inches on Plate A profile paper $=\frac{125}{N}$.

By these formulas and Table VII the engineer plats the grade line on the profile and calculates the elevation of grade for each station before going into the field. The P. I.'s should be made at even stations, and the ends of curve can usually be made at stations without causing faulty grades. This greatly simplifies the calculations which have to be tried and repeated until the grade line is satisfactory. Straight grades can usually be expressed with one decimal place, and never more than two should be used, except when **compensating for curvature** on maximum grades.

33. When laying a maximum grade, or where uniform resistance is desired, the rate of grade should be made less on curves than on tangents by the amounts shown in column 8, Table VI. In the lower portions of such a grade, where high velocities are admissible, and can be had, compensation for curvature is unnecessary. But where the velocity may fall to eight miles per hour curve resistance should be fully compensated in the grade, so that the resistance and velocity will be uniform. If the velocity drops so the centrifugal force is lost the

train "stalls." A maximum grade in a district is not necessarily one of maximum ratio, but one which produces a maximum tractive power, where curves and velocity are considered. It is desired to avoid entering the field so ably covered by the late A. M. Wellington in his Economic Theory of Railway Location; but that statement is necessary to support the new principle advocated, viz.:

34. That more easy vertical curves should be introduced into railway grades to supersede long, straight grades which cause sharp summits and sags. Long, easy, vertical curves, reversing in the middle of a hill, can be used with great advantage, especially if the rate of grade at the P. R. C. *be not held down* to the same rate allowable on a straight grade several miles long. "Momentum" grades can be used nowhere to a better advantage than at a P. R. C. of vertical curves. Curves are more difficult to plot upon the profile, but they are well worth the trouble. A large percentage of straight grade generally causes sharper curves, which are very objectionable in a grade line. This is for the same reason that a sharper curvature gives larger percentage of tangent in horizontal alinement. Establishing grade is a capital service, where skill, time, and care are well spent in projecting curves.

TABLES

AND

DIAGRAMS.

TABLE I.

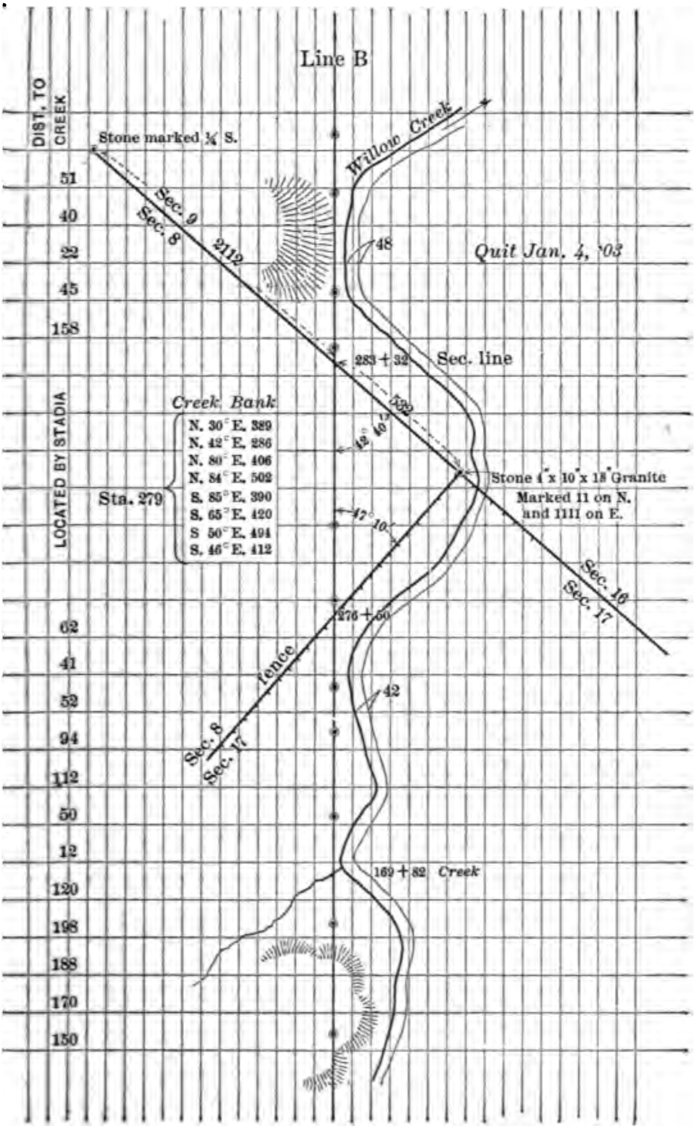
DIFFERENCES IN LENGTHS OF ARCS AND CORRESPONDING CHORDS.

Degree of Curve.	Lengths of Arc.									
	100	90	80	70	60	50	40	30	20	10
1°	.001	.001	.001	.001						
2°	.005	.004	.003	.002	.001					
3°	.011	.009	.006	.004	.002	.001				
4°	.020	.015	.010	.007	.004	.002	.001			
5°	.031	.023	.016	.011	.007	.004	.002			
6°	.045	.033	.023	.015	.010	.006	.003	.001		
7°	.062	.045	.031	.021	.013	.008	.004	.002		
8°	.081	.059	.041	.028	.017	.010	.005	.002		
9°	.103	.075	.053	.036	.022	.013	.006	.003		
10°	.127	.093	.065	.044	.027	.016	.008	.003	.001	
11°	.154	.113	.079	.053	.033	.019	.010	.004	.001	
12°	.184	.134	.094	.063	.040	.022	.012	.005	.001	
13°	.216	.158	.110	.074	.046	.027	.014	.006	.002	
14°	.250	.183	.127	.086	.054	.032	.016	.007	.002	
15°	.286	.209	.146	.099	.062	.036	.018	.008	.002	
16°	.324	.236	.166	.112	.070	.041	.021	.009	.003	
17°	.365	.266	.187	.126	.079	.046	.023	.010	.003	
18°	.409	.298	.209	.141	.088	.051	.026	.011	.003	
19°	.456	.333	.233	.157	.098	.057	.029	.012	.004	
20°	.507	.370	.259	.174	.109	.064	.032	.014	.004	
25°	.792	.580	.407	.273	.172	.099	.051	.021	.006	
30°	1.136	.830	.580	.390	.245	.142	.072	.031	.009	.001
40°	2.018	1.480	1.036	.695	.435	.252	.130	.054	.016	.002
50°	3.144	2.270	1.60	1.086	.686	.393	.200	.085	.025	.003
60°	4.507	3.300	2.31	1.550	.970	.564	.290	.121	.036	.004
100°	12.218									
180°	36.3									

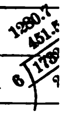
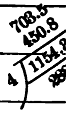
This table was calculated by the following formula.

$$\text{Difference} = 100 - \frac{11459.16 \times \sin \tfrac{1}{2} \text{ degree}}{\text{degree}}$$

II. SAMPLE TRANSIT NOTES.



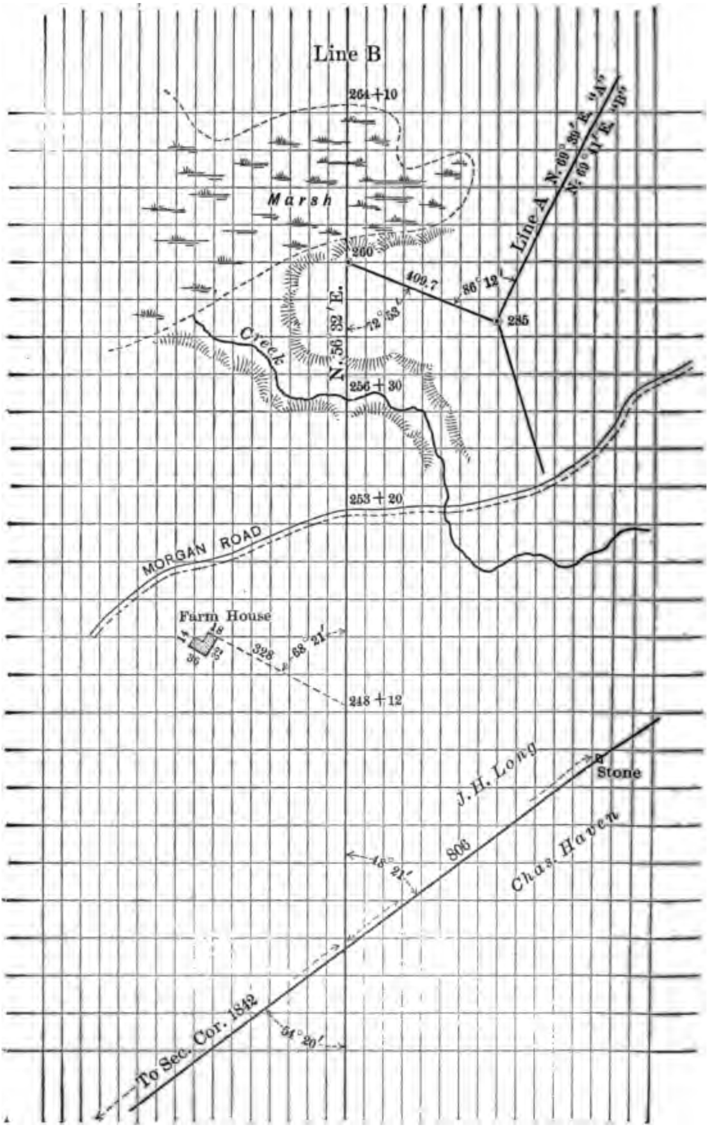
Jan. 5 '03

STATION	DEF.			C.C.	M.C.
+ 44 P.T.	2°55'			N. 20°20' E.	
9	2°22'				
			Whole Angle		
8	0°8'		Cir. Curve	16°12'	
+ 94 P.S.	8°06'	6° Curve L. with # 9 Spirals	Spirals	9°00'	
7	5°17'		Total	25°12'	
6	2°17'		Tang.	288.7	
+ 24 P.C.	1°35'				
5	1°09'		P.I. 286 + 62.7 not set		
4	0°6'				
+ 74 P.S.					
3					
2					
1					
280					
9 P.O.T.					N. 35°30
8				N. 45°32' E.	
7 + 00 P.T.	2°55'				
6	1°57'				
			Whole Angle		
5	0°27'		Cir. Curve	5°00'	
+ 75 P.S.	2°30'	4° Curve L. with # 9 Spirals	Spirals	9°00'	
4	1°00'		Total	14°00'	
+ 50 P.C.	1°35'				
3	1°00'		Tang.	288.6	
2	0°14'		P.I. 274 + 13.6		
+ 25 P.S.					
1					
270				N. 59°32' E.	
9					N. 49°
+ 40 P.T.	1°30'	1° Curve R.			
8	1°18'				
			Whole Angle 3°00'		
7	48'		Tang.	150.1	
			P.I. 266 + 90.1		
6	18'				
+ 40 P.C.					
265					

Jan. 5 '03

STATION	DEF			C.C.	M.C.
4				N. 89°29′ E.	
+ 40 P.T. 3	4°35′ 3°00′				
2 + 00 P.S.	18°00′		Whole Angle Cir. Curve	 36°00′	
1	13°00′	10° Curve R. with # 14 Spirals	Spirals Total	14°00′ 50°00′	
310	8°00′				
9	3°00′		Secant	61.00	
+ 40 P.C. 8	2°25′ 0°51′		Tang. P.I. 310	337.8 + 37.8	2671.7 706.7 10)3378.4 337.8
7 + 0 P.S.					
6				N. 39°29′ E.	
5 + 00 P.T.	1°35′				N. 29°30′ E.
4 + 00 P.S.	8°10½′		Whole Angle Cir. Curve	 16°21′	
3	5°40½′	5° Curve L. with # 5 Spirals	Spirals Total	5°00′ 21°21′	1080.0 250.5 5)1330.5 266.1
+ 50 P.O.C. 2	4°25½′ 3°10½′		Ex. Sec.	20.7	
1	0°40½′		Tang.	266.1	
+ 73 P.C. 300	0°55′ 0°05′				
+ 73 P.R.C. 9	2°55′ 1°41′			N. 60°50′ E.	
+ 48 P.S. 8	15°45′ 13°50′		Cir. Curve	31°30′	
7	9°50′	8° Curve R. with # 9 Spirals	Spirals Total	9°00′ 40°30′	
6	5°50′		P.I. 296	+ 50 set	
5	1°50′		Tang.	320.8	2113.7 452.5 8)2566.2 320.8
+ 54.2 P.C. 4	1°35′ 0°32′				
+ 29.2 P.S. 3					
2					
1				N. 20°20′ E.	
200					N. 10°15′ E.

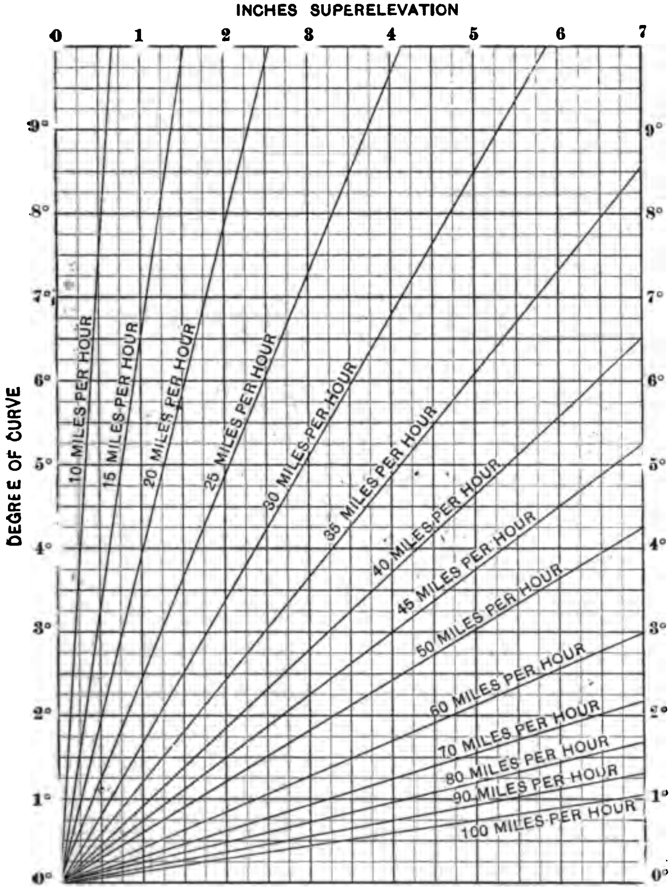
II. SAMPLE TRANSIT NOTES.



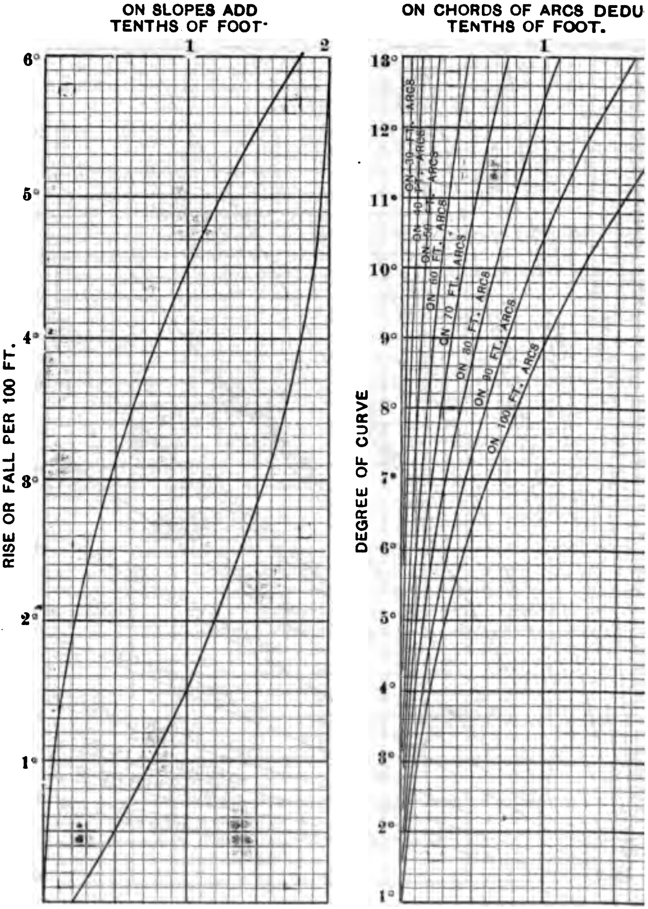
III. SUPERELEVATION OF OUTER RAIL ON CURVES. STANDARD GAUGE TRACK.

IN INCHES = DEGREE × VELOCITY^2 (IN MI. PER H.) × .00065.

Superelevation for other gauges are proportional to gauge.



IV. DIAGRAM OF CORRECTIONS FOR MEASURI



CURVES OF CIVIL ENGINEERING

The Transitman's Pocket Companion–treating of Circula Transition and Vertical Curves, with 72 pages of Tables and Diagrams needed in Field Work. Price $2.50

This is to call the attention of Railroad and Municipal Engineers, and those who build Tramways, Roads, Boulevards, Trolley lines, Pipe lines, Canals, etc., to the above named new publication, which is indispensable in laying out sharp curves.

Other existing field books only claim to be suited to railroad curves, and are in fact suitable only for the easier railroad curves. They provide for measuring on chords, while the new system makes the measurements on the curve; so that a 500 degree curve has a clear and definite meaning. The mere idea of measuring across a chord 100 ft. and calling it the length of the line, is revolting. It might be excusable if it resulted in simplicity. But it results in a maze of difficulties.

The difficulties are so great that not a curve is shown on any of the filed plats of irrigation canals in Colorado aggregating 10,000 miles. It is generally found everywhere that only railroad surveys show curves. Their alignments are all attempted to be shown by straight lines and angles. Is it not time to improve upon George Washington's method of surveying? Stake out the center line. Put in curves where needed. It is no longer difficult and uncertain work. Some advocate using 50 or 25 ft. chords, but this is temporizing. It leaves the engineer without tables whereby he can even determine his radius. It is far simpler to follow the curve and keep certain knowledge of distance and grade. This system, only four months old, is widely distributed; but if not found with local dealers it may be procured of the author.

A. M. Haynes,

37 South Lincoln Avenue, Denver.

RISE OR FALL PER 100 FT.

TABLE V.

NATURAL SINES.

Angle. ° ′	Sine.	Dif. 1′.	Angle. ° ′	Sine.	Dif. 1′.	Angle. ° ′	Sine.	Dif. 1′.
0 34½	.01	.00029	20 29	.35	.00027	42 51	.68	.00021
1 09	.02	"	21 06	.36	"	43 38	.69	.00021
1 43	.03	"	21 43	.37	"	44 26	.70	.00021
2 17½	.04	"	22 20	.38	"	45 14	.71	.00021
2 52	.05	"	22 57	.39	"	46 03½	.72	.00020
3 26½	.06	"	23 35	.40	"	46 53	.73	.00020
4 01	.07	"	24 12½	.41	"	47 44	.74	.00020
4 35½	.08	"	24 50	.42	.00026	48 35½	.75	.00019
5 10	.09	"	25 28	.43	"	49 28	.76	.00019
5 44½	.10	"	26 06	.44	"	50 21	.77	.00019
6 19	.11	"	26 44½	.45	"	51 16	.78	.00018
6 53½	.12	"	27 23	.46	"	52 11	.79	.00018
7 28	.13	"	28 02	.47	"	53 08	.80	.00017
8 03	.14	"	28 41	.48	.00025	54 06	.81	.00017
8 37½	.15	"	29 20½	.49	"	55 05	.82	.00017
9 12½	.16	"	30 00	.50	"	56 06	.83	.00016
9 47	.17	"	30 40	.51	"	57 08½	.84	.00016
10 22	.18	"	31 20	.52	"	58 13	.85	.00015
10 57	.19	"	32 00	.53	"	59 19	.86	.00015
11 32	.20	"	32 41	.54	.00024	60 27½	.87	.00014
12 07½	.21	"	33 22	.55	"	61 39	.88	.00014
12 43½	.22	.00028	34 03½	.56	"	62 52	.89	.00013
13 18	.23	"	34 45	.57	"	64 10	.90	.00013
13 53	.24	"	35 27	.58	"	65 30	.91	.00012
14 29	.25	"	36 09½	.59	.00023	66 56	.92	.00011
15 04	.26	"	36 52	.60	"	68 26	.93	.00011
15 40	.27	"	37 35½	.61	"	70 03	.94	.00010
16 15½	.28	"	38 19	.62	"	71 48	.95	.00009
16 51½	.29	"	39 03	.63	"	73 45	.96	.00008
17 27½	.30	"	39 47½	.64	.00022	75 56	.97	.00007
18 03½	.31	"	40 32½	.65	"	78 31½	.98	.00006
18 40	.32	"	41 18	.66	"	81 54	.99	.00004
19 16	.33	.00027	42 04	.67	"	90 00	1.00	.00000
19 52½	.34	"						

TABLE VI.

CURVE CHARACTERISTICS.

Degree.	Radius.	For a 100-Foot Arc. Middle Ordinate.	Quarter Ordinate.	Tang. Distance.	Chord.	Diff. in Lengths of Rails per 100 Feet.	Grade of Equivalent Resistance.	Track Gauge. ′	″
1	2	3	4	5	6	7	8	9	
°								′	″
½	11459.16	.109	.082	.44	100.000	.0410	0.015	4	8½
1	5729.58	.218	.163	.87	99.999	.0820	0.03	4	8½
1½	3819.72	.327	.245	1.31	99.997	.1230	0.045	4	8½
2	2864.79	.436	.328	1.74	99.995	.1640	0.06	4	8½
2½	2291.84	.545	.408	2.18	99.992	.2050	0.075	4	8½
3	1909.86	.655	.490	2.62	99.989	.2461	0.09	4	8⅝
3½	1637.02	.764	.573	3.05	99.985	.2871	0.10	4	8⅝
4	1432.40	.873	.655	3.49	99.980	.3281	0.11	4	8⅝
5	1145.92	1.090	.82	4.36	99.969	.4101	0.14	4	8⅝
6	954.93	1.309	.98	5.23	99.955	.4922	0.16	4	8⅝
7	818.51	1.53	1.15	6.10	99.938	.5742	0.18	4	8⅞
8	716.20	1.75	1.38	7.0	99.919	.6562	0.20	4	8⅞
9	636.62	1.96	1.47	7.9	99.897	.7383	0.22	4	9
10	572.96	2.18	1.63	8.7	99.873	.8203	0.24	4	9
11	520.87	2.40	1.80	9.6	99.846	.9024	0.26	4	9
12	477.46	2.62	1.97	10.4	99.816	.9844	0.28	4	9
13	440.74	2.84	2.13	11.3	99.784	1.0664	0.30	4	9⅛
14	409.25	3.05	2.29	12.2	99.750	1.1484	0.32	4	9⅛
15	381.98	3.27	2.46	13.0	99.714	1.2300	0.34	4	9⅛
16	358.10	3.49	2.62	13.9	99.676	1.3124	0.36	4	9⅛
18	318.31	3.92	2.94	15.6	99.591	1.4766	0.38	4	9¼
20	286.48	4.36	3.28	17.4	99.493	1.6406	0.40	4	9¼
25	229.18	5.43			99.208				
30	190.99	6.51			98.864				
35	163.70	7.61			98.464				
40	143.24	8.64			97.981				
50	114.59	10.75			96.856				
60	95.49	12.80			95.493				
180	31.83	31.83			63.66				

Columns 7, 8, and 9 refer to standard gauge railroad track.

Column 5 is the distance of curve from tangent 100 feet from point of tangency and equals half the chord deflection.

To find any radius not here shown, divide 5729.58 by the degree of curvature.

To find radius of an old-style curve located with 100-ft. chords, add 07 × degree of curve to tabular quantity.

TABLE VII.

ORDINATES FROM TANGENT TO VERTICAL CURVES FOR EACH 100 FEET FROM P. C.

No.	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
1	.01	.02	.04	.08	.12	.18	.25	.32	.40	.50	.60	.72	.84	.98
2	.01	.04	.09	.16	.25	.36	.49	.64	.81	1.00	1.21	1.44	1.69	1.96
2½	.01	.05	.11	.20	.31	.45	.61	.80	1.01	1.25	1.51	1.80	2.11	2.45
3	.01	.06	.14	.24	.38	.54	.74	.96	1.21	1.50	1.81	2.16	2.53	2.94
3½	.02	.07	.16	.28	.44	.63	.86	1.12	1.42	1.75	2.12	2.52	2.96	3.44
4	.02	.08	.18	.32	.50	.72	.98	1.28	1.62	2.00	2.42	2.88	3.38	3.92
4½	.02	.09	.20	.36	.56	.81	1.10	1.44	1.82	2.25	2.72	3.24	3.80	4.41
5	.03	.10	.22	.40	.62	.90	1.22	1.60	2.02	2.50	3.02	3.60	4.22	4.89
5½	.03	.11	.25	.44	.69	.99	1.35	1.76	2.23	2.75	3.33	3.96	4.65	5.39
6	.03	.12	.27	.48	.75	1.08	1.47	1.92	2.43	3.00	3.63	4.32	5.07	5.88
6½	.03	.13	.29	.52	.81	1.17	1.59	2.08	2.63	3.25	3.93	4.68	5.49	6.37
7	.04	.14	.31	.56	.87	1.26	1.71	2.24	2.83	3.50	4.24	5.05	5.91	6.86
7½	.04	.15	.34	.60	.93	1.35	1.84	2.40	3.04	3.75	4.54	5.40	6.34	7.35
8	.04	.16	.36	.64	1.00	1.44	1.96	2.56	3.24	4.00	4.84	5.76	6.76	7.84
8½	.04	.17	.38	.68	1.06	1.53	2.08	2.72	3.44	4.25	5.14	6.12	7.18	8.33
9	.05	.18	.40	.72	1.12	1.62	2.20	2.88	3.64	4.50	5.44	6.48	7.60	8.82
9½	.05	.19	.43	.76	1.19	1.71	2.33	3.04	3.85	4.75	5.75	6.84	8.03	9.31
10	.05	.20	.45	.80	1.25	1.80	2.45	3.20	4.05	5.00	6.05	7.20	8.45	9.80
11	.06	.22	.49	.88	1.40	1.98	2.69	3.52	4.45	5.50	6.65	7.92	9.29	10.78
12	.06	.24	.54	.96	1.50	2.16	2.94	3.84	4.86	6.00	7.26	8.64	10.14	11.76
13	.07	.26	.59	1.04	1.63	1.34	3.18	4.16	5.27	6.50	7.87	9.36	10.99	12.74
14	.07	.28	.63	1.12	1.75	2.52	3.43	4.48	5.67	7.00	8.47	10.10	11.83	13.72
15	.08	.30	.67	1.20	1.87	2.70	3.67	4.80	6.07	7.50	9.08	10.80	12.67	14.70
16	.08	.32	.72	1.28	2.00	2.88	3.92	5.12	6.48	8.00	9.68	11.52	13.52	15.68
17	.09	.34	.76	1.36	2.12	3.06	4.16	5.44	6.88	8.50	10.28	12.24	14.36	16.66
18	.09	.36	.81	1.44	2.25	3.24	4.41	5.76	7.29	9.00	10.89	12.96	15.21	17.64
19	.10	.38	.85	1.52	2.37	3.42	4.65	6.08	7.69	9.50	11.49	13.68	16.05	18.62
20	.10	.40	.90	1.60	2.50	3.60	4.90	6.40	8.10	10.00	12.10	14.40	16.90	19.60

TABLE VIII.

AZIMUTH OF POLARIS WHEN AT ELONGATION.

Lat.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	Lat.
4°	1° 13′	1° 13′	1° 12′	1° 12′	1° 11′	1° 11′	1° 11′	1° 11′	1° 10′	4°
8°	1° 13′	1° 13′	1° 13′	1° 12′	1° 12′	1° 12′	1° 11′	1° 11′	1° 11′	8°
12°	1° 14′	1° 14′	1° 14′	1° 13′	1° 13′	1° 13′	1° 12′	1° 12′	1° 12′	12°
16°	1° 15′	1° 15′	1° 15′	1° 15′	1° 14′	1° 14′	1° 14′	1° 13′	1° 13′	16°
20°	1° 17′	1° 17′	1° 17′	1° 16′	1° 16′	1° 16′	1° 15′	1° 15′	1° 14′	20°
24°	1° 19′	1° 19′	1° 19′	1° 19′	1° 18′	1° 18′	1° 18′	1° 17′	1° 17′	24°
26°	1° 21′	1° 21′	1° 20′	1° 20′	1° 19′	1° 19′	1° 19′	1° 18′	1° 18′	26°
28°	1° 22′	1° 22′	1° 22′	1° 21′	1° 21′	1° 20′	1° 20′	1° 20′	1° 20′	28°
30°	1° 24′	1° 24′	1° 23′	1° 23′	1° 22′	1° 22′	1° 22′	1° 21′	1° 21′	30°
32°	1° 26′	1° 25′	1° 25′	1° 24′	1° 24′	1° 24′	1° 23′	1° 23′	1° 23′	32°
34°	1° 28′	1° 27′	1° 27′	1° 26′	1° 26′	1° 26′	1° 25′	1° 25′	1° 25′	34°
36°	1° 30′	1° 29′	1° 29′	1° 29′	1° 28′	1° 28′	1° 27′	1° 27′	1° 27′	36°
38°	1° 32′	1° 32′	1° 31′	1° 31′	1° 31′	1° 30′	1° 30′	1° 29′	1° 29′	38°
40°	1° 35′	1° 34′	1° 34′	1° 34′	1° 33′	1° 33′	1° 32′	1° 32′	1° 32′	40°
42°	1° 38′	1° 37′	1° 37′	1° 37′	1° 36′	1° 36′	1° 35′	1° 35′	1° 34′	42°
44°	1° 41′	1° 41′	1° 40′	1° 40′	1° 39′	1° 39′	1° 38′	1° 38′	1° 37′	44°
46°	1° 45′	1° 44′	1° 44′	1° 43′	1° 43′	1° 42′	1° 42′	1° 41′	1° 41′	46°
48°	1° 49′	1° 48′	1° 48′	1° 47′	1° 47′	1° 46′	1° 46′	1° 45′	1° 45′	48°
50°	1° 53′	1° 53′	1° 52′	1° 52′	1° 51′	1° 51′	1° 50′	1° 50′	1° 49′	50°

TABLE IX.

TANGENT DISTANCES, LONG CHORDS, AND EXTERNAL SECANTS OF A ONE-DEGREE CURVE.

Also amounts to be added to same when No. 5, No. 9, and No. 14 Spirals are to be used.

To find corresponding functions of any other curve divide tabular number by degree of curvature.

Formulas used in construction of table:

$$\text{Long chord} = 2 \times 5729.58 \times \sin a,$$

$$\text{Tangent} = 5729.58 \times \tan a;$$

$$\text{External sec} = 5729.58 \div \cos a - 5729.58;$$

where $a = \frac{1}{2}$ whole angle of curve.

With Metric System.

Using 20-meter chords, divide tabular quantities by five times the proposed metric degree of curve for corresponding quantities in metric measure.

This table is exact for arc measurements and is as accurate as any table like it for the chord-measurement method for laying out curves.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
1°	50.0	100.0	0.22	1°
2′	51.67	103.3	0.24	2′
4′	53.33	106.7	0.25	4′
6′	55.00	110.0	0.27	6′
8′	56.67	113.3	0.28	8′
10′	58.33	116.7	0.30	10′
12′	60.00	120.0	0.31	12′
14′	61.67	123.3	0.33	14′
16′	63.33	126.7	0.35	16′
18′	65.00	130.0	0.37	18′
20′	66.67	133.3	0.39	20′
22′	68.33	136.7	0.41	22′
24′	70.00	140.0	0.43	24′
26′	71.67	143.3	0.45	26′
28′	73.34	146.7	0.47	28′
30′	75.00	150.0	0.49	30′
32′	76.67	153.3	0.51	32′
34′	78.34	156.7	0.54	34′
36′	80.00	160.0	0.56	36′
38′	81.67	163.3	0.58	38′
40′	83.34	166.7	0.60	40′
42′	85.00	170.0	0.63	42′
44′	86.67	173.3	0.65	44′
46′	88.34	176.7	0.68	46′
48′	90.01	180.0	0.71	48′
50′	91.68	183.3	0.73	50′
52′	93.34	186.7	0.76	52′
54′	95.01	190.0	0.79	54′
56′	96.68	193.3	0.81	56′
58′	98.34	196.7	0.84	58′
2°	100.01	200.0	0.87	2°
2′	101.67	203.3	0.90	2′
4′	103.34	206.6	0.93	4′
6′	105.01	210.0	0.96	6′
8′	106.68	213.3	0.99	8′
10′	108.35	216.6	1.02	10′
12′	110.02	220.0	1.06	12′
14′	111.68	223.3	1.09	14′
16′	113.35	226.6	1.12	16′
18′	115.01	230.0	1.15	18′
20′	116.68	233.3	1.19	20′
22′	118.35	236.6	1.23	22′
24′	120.02	240.0	1.26	24′
26′	121.68	243.3	1.30	26′
28′	123.35	246.6	1.33	28′

When Spiral No. 5 is used add amounts found in this column after 5°.
" " 9 " " " " " " " 9°.
" " 14 " " " " " " " 14°.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
2° 30′	125.02	250.0	1.36	**2°** 30′
32′	126.69	253.3	1.39	32′
34′	128.35	256.6	1.43	34′
36′	130.02	260.0	1.47	36′
38′	131.69	263.3	1.51	38′
40′	133.36	266.6	1.55	40′
42′	135.03	270.0	1.59	42′
44′	136.70	273.3	1.63	44′
46′	138.36	276.6	1.67	46′
48′	140.03	280.0	1.71	48′
50′	141.70	283.3	1.75	50′
52′	143.36	286.6	1.79	52′
54′	145.03	290.0	1.83	54′
56′	146.70	293.3	1.88	56′
58′	148.37	296.6	1.92	58′
3°	150.04	300.0	1.96	**3°**
2′	151.71	303.3	2.01	2′
4′	153.38	306.6	2.05	4′
6′	155.04	309.9	2.09	6′
8′	156.71	313.3	2.14	8′
10′	158.38	316.6	2.19	10′
12′	160.05	319.9	2.24	12′
14′	161.72	323.3	2.29	14′
16′	163.38	326.6	2.34	16′
18′	165.05	329.9	2.38	18′
20′	166.72	333.3	2.43	20′
22′	168.38	336.6	2.48	22′
24′	170.05	339.9	2.52	24′
26′	171.72	343.3	2.57	26′
28′	173.39	346.6	2.62	28′
30′	175.06	349.9	2.67	30′
32′	176.73	353.3	2.72	32′
34′	178.40	356.6	2.77	34′
36′	180.07	359.9	2.82	36′
38′	181.74	363.3	2.87	38′
40′	183.40	366.6	2.93	40′
42′	185.07	369.9	2.98	42′
44′	186.74	373.3	3.04	44′
46′	188.40	376.6	3.10	46′
48′	190.07	379.9	3.15	48′
50′	191.74	383.3	3.21	50′
52′	193.40	386.6	3.26	52′
54′	195.07	389.9	3.32	54′
56′	196.74	393.3	3.38	56′
58′	198.41	396.6	3.44	58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
4°	200.08	399.9	3.49	4°
2′	201.75	403.3	3.55	2′
4′	203.42	406.6	3.61	4′
6′	205.09	409.9	3.67	6′
8′	206.76	413.3	3.73	8′
10′	208.43	416.6	3.79	10′
12′	210.10	419.9	3.85	12′
14′	211.77	423.3	3.92	14′
16′	213.43	426.6	3.98	16′
18′	215.10	429.9	4.04	18′
20′	216.77	433.3	4.10	20′
22′	218.44	436.6	4.16	22′
24′	220.11	439.9	4.22	24′
26′	221.78	443.2	4.28	26′
28′	223.45	446.6	4.35	28′
30′	225.12	449.9	4.42	30′
32′	226.79	453.2	4.48	32′
34′	228.46	456.6	4.55	34′
36′	230.13	459.9	4.62	36′
38′	231.80	463.2	4.69	38′
40′	233.47	466.6	4.76	40′
42′	235.14	469.9	4.82	42′
44′	236.81	473.2	4.89	44′
46′	238.48	476.6	4.96	46′
48′	240.15	479.9	5.03	48′
50′	241.81	483.2	5.10	50′
52′	243.48	486.5	5.17	52′
54′	245.15	489.9	5.24	54′
56′	246.82	493.2	5.31	56′
58′	248.49	496.5	5.38	58′
5°	250.16	499.9	5.46	5°
2′	251.83	503.2	5.53	2′
4′	253.50	506.5	5.60	4′
6′	255.17	509.9	5.68	6′
8′	256.84	513.2	5.75	8′
10′	258.51	516.5	5.83	10′
12′	260.18	519.9	5.90	12′
14′	261.85	523.2	5.98	14′
16′	263.52	526.5	6.06	16′
18′	265.19	529.8	6.13	18′
20′	266.86	533.2	6.21	20′
22′	268.53	536.5	6.29	22′
24′	270.20	539.8	6.37	24′
26′	271.87	543.2	6.45	26′
28′	273.54	546.5	6.53	28′

Add 250.1 for Spiral No. 5.

Add 2.5 for Spiral No. 5.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
5° 30′	275.21		549.8	6.61		**5°** 30′
32′	276.88		553.2	6.69		32′
34′	278.56		556.5	6.77		34′
36′	280.23		559.8	6.85	Add 2.5 for Spiral No. 5.	36′
38′	281.90		563.2	6.93		38′
40′	283.57		566.5	7.01		40′
42′	285.24		569.8	7.09		42′
44′	286.91		573.2	7.17		44′
46′	288.58		576.5	7.25		46′
48′	290.25		579.8	7.34		48′
50′	291.92		583.1	7.43		50′
52′	293.59		586.5	7.51		52′
54′	295.26		589.8	7.60		54′
56′	296.93		593.1	7.68		56′
58′	298.60		596.5	7.77		58′
6°	300.28		599.8	7.85		**6°**
2′	301.95		603.1	7.94		2′
4′	303.63		606.5	8.03		4′
6′	305.30	Add 250.1 for Spiral No. 5.	609.8	8.12		6′
8′	306.97		613.1	8.21		8′
10′	308.64		616.4	8.30		10′
12′	310.31		619.8	8.39		12′
14′	311.98		623.1	8.48		14′
16′	313.66		626.4	8.57		16′
18′	315.33		629.7	8.66		18′
20′	317.00		633.1	8.75		20′
22′	318.67		636.4	8.84		22′
24′	320.34		639.7	8.94	Add 2.6 for Spiral No. 5.	24′
26′	322.01		643.1	9.03		26′
28′	323.68		646.4	9.13		28′
30′	325.35		649.7	9.23		30′
32′	327.02		653.0	9.32		32′
34′	328.70		656.4	9.42		34′
36′	330.37		659.7	9.52		36′
38′	332.04		663.0	9.62		38′
40′	333.71		666.3	9.71		40′
42′	335.39		669.7	9.81		42′
44′	337.06		673.0	9.91		44′
46′	338.73		676.3	10.00		46′
48′	340.40		679.6	10.10		48′
50′	342.08		783.0	10.20		50′
52′	343.75		686.3	10.30		52′
54′	345.42		689.6	10.40		54′
56′	347.10		692.9	10.50		56′
58′	348.77		696.3	10.60		58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
7°	350.44	699.6	10.71	**7°**
2′	352.11	702.9	10.81	2′
4′	353.78	706.2	10.91	4′
6′	355.45	709.5	11.01	6′
8′	357.12	712.9	11.11	8′
10′	358.80	716.2	11.22	10′
12′	360.47	719.5	11.32	12′
14′	362.14	722.8	11.43	14′
16′	363.82	726.2	11.53	16′
18′	365.49	729.5	11.64	18′
20′	367.17	732.8	11.75	20′
22′	368.84	736.1	11.85	22′
24′	370.51	739.5	11.96	24′
26′	372.19	742.8	12.07	26′
28′	373.86	746.1	12.18	28′
30′	375.54	749.4	12.29	30′
32′	377.21	752.8	12.40	32′
34′	378.88	756.1	12.51	34′
36′	380.56	759.4	12.63	36′
38′	382.23	762.8	12.74	38′
40′	383.91	766.1	12.85	40′
42′	385.58	769.4	12.96	42′
44′	387.25	772.7	13.08	44′
46′	388.93	776.1	13.19	46′
48′	390.61	779.4	13.30	48′
50′	392.28	782.7	13.41	50′
52′	393.95	786.0	13.53	52′
54′	395.62	789.4	13.64	54′
56′	397.30	792.7	13.76	56′
58′	398.97	796.0	13.88	58′
8°	400.65	799.4	13.99	**8°**
2′	402.33	802.7	14.10	2′
4′	404.00	806.0	14.22	4′
6′	405.67	809.3	14.34	6′
8′	407.35	812.6	14.46	8′
10′	409.03	816.0	14.58	10′
12′	410.70	819.3	14.70	12′
14′	412.38	822.6	14.82	14′
16′	414.06	825.9	14.94	16′
18′	415.74	829.3	15.06	18′
20′	417.41	832.6	15.18	20′
22′	419.08	835.9	15.30	22′
24′	420.76	839.2	15.43	24′
26′	422.44	842.6	15.55	26′
28′	424.11	845.9	15.67	28′

Add 250.1 for Spiral No. 5.

Add 2.6 for Spiral No. 5.

Add 250.2 for Spiral No. 5.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
8° 30′	425.79	849.2	15.80	**8°** 30′
32′	427.47	852.5	15.93	32′
34′	429.15	855.8	16.06	34′
36′	430.83	859.2	16.19	36′
38′	432.50	862.5	16.31	38′
40′	434.17	865.8	16.43	40′
42′	435.85	869.1	16.56	42′
44′	437.53	872.5	16.69	44′
46′	439.20	875.8	16.81	46′
48′	440.88	879.1	16.94	48′
50′	442.55	882.4	17.07	50′
52′	454.23	885.7	17.20	52′
54′	455.90	889.1	17.33	54′
56′	457.58	892.4	17.46	56′
58′	459.26	895.7	17.59	58′
9°	450.93	899.0	17.72	**9°**
2′	452.60	902.3	17.83	2′
4′	454.28	905.6	17.97	4′
6′	455.96	909.0	18.10	6′
8′	457.64	912.3	18.26	8′
10′	459.32	915.7	18.38	10′
12′	471.00	919.0	18.52	12′
14′	472.68	922.4	18.65	14′
16′	474.36	925.7	18.79	16′
18′	476.04	929.0	18.93	18′
20′	467.71	932.3	19.06	20′
22′	469.39	935.6	19.19	22′
24′	471.07	939.0	19.33	24′
26′	472.75	942.3	19.49	26′
28′	474.42	945.6	19.62	28′
30′	476.10	948.9	19.75	30′
32′	477.78	952.2	19.89	32′
34′	479.46	955.5	20.03	34′
36′	481.13	958.9	20.17	36′
38′	482.81	962.2	20.31	38′
40′	484.49	965.5	20.45	40′
42′	486.17	968.9	20.59	42′
44′	487.84	972.2	20.74	44′
46′	489.52	975.5	20.88	46′
48′	491.20	978.8	21.02	48′
50′	492.88	982.1	21.16	50′
52′	494.56	985.4	21.30	52′
54′	496.24	988.7	21.45	54′
56′	497.92	992.0	21.59	56′
58′	499.60	995.3	21.74	58′

Add 250.2 for Spiral No. 5.
" 450.5 " " " 9.

Add 2.6 for Spiral No. 5.
" 7.2 " " " 9.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
10°	501.28	998.7	21.89	**10°**
2′	502.96	1002.0	22.04	2′
4′	504.64	1005.4	22.18	4′
6′	506.32	1008.7	22.33	6′
8′	508.0	1012.0	22.48	8′
10′	509.68	1015.3	22.63	10′
12′	511.36	1018.7	22.78	12′
14′	513.04	1022.0	22.93	14′
16′	514.72	1025.3	23.08	16′
18′	516.40	1028.6	23.23	18′
20′	518.08	1031.9	23.38	20′
22′	519.76	1035.3	23.53	22′
24′	521.44	1038.6	23.69	24′
26′	523.12	1041.9	23.84	26′
28′	524.80	1045.2	23.99	28′
30′	526.48	1048.5	24.14	30′
32′	528.16	1051.8	24.30	32′
34′	529.84	1055.2	24.45	34′
36′	531.52	1058.5	24.60	36′
38′	533.20	1061.8	24.75	38′
40′	534.88	1065.1	24.91	40′
42′	536.76	1068.4	25.06	42′
44′	538.44	1071.7	25.22	44′
46′	540.12	1075.0	25.37	46′
48′	541.80	1078.4	25.54	48′
50′	543.29	1081.7	25.70	50′
52′	544.97	1085.0	25.86	52′
54′	546.65	1088.4	26.02	54′
56′	548.33	1091.7	26.18	56′
58′	550.02	1095.0	26.34	58′
11°	551.70	1098.3	26.50	**11°**
2′	553.38	1101.6	26.66	2′
4′	555.06	1105.0	26.83	4′
6′	556.74	1108.3	26.99	6′
8′	558.43	1111.6	27.15	8′
10′	560.11	1114.9	27.31	10′
12′	561.80	1118.3	27.47	12′
14′	563.48	1121.6	27.64	14′
16′	565.16	1124.9	27.80	16′
18′	566.84	1128.2	27.97	18′
20′	568.53	1131.5	28.14	20′
22′	570.22	1134.8	28.30	22′
24′	571.90	1138.1	28.47	24′
26′	573.58	1141.4	28.64	26′
28′	575.26	1144.7	28.80	28′

Add 250.2 for Spiral No. 5.
" 450.5 " " " 9.

Add 2.6 for Spiral No. 5.
" 7.2 " " " 9.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
11° 30′	576.95	1148.0	28.97	**11°** 30′
32′	578.63	1151.4	29.14	32′
34′	580.32	1154.7	29.31	34′
36′	582.00	1158.0	29.48	36′
38′	583.69	1161.3	29.65	38′
40′	585.37	1164.6	29.82	40′
42′	587.05	1168.0	30.00	42′
44′	588.73	1171.3	30.17	44′
46′	590.42	1174.6	30.34	46′
48′	592.10	1177.9	30.51	48′
50′	593.79	1181.2	30.68	50′
52′	595.47	1184.6	30.85	52′
54′	597.16	1187.9	31.02	54′
56′	598.84	1191.2	31.20	56′
58′	600.53	1194.5	31.37	58′
12°	602.21	1197.8	31.56	**12°**
2′	603.89	1201.2	31.73	2′
4′	605.58	1204.5	31.91	4′
6′	607.27	1207.8	32.09	6′
8′	608.96	1211.1	32.27	8′
10′	610.64	1214.4	32.45	10′
12′	612.32	1217.7	32.63	12′
14′	614.01	1221.0	32.81	14′
16′	615.70	1224.3	33.00	16′
18′	617.38	1227.6	33.18	18′
20′	619.07	1230.9	33.35	20′
22′	620.76	1234.3	33.53	22′
24′	622.45	1237.6	33.71	24′
26′	624.13	1240.9	33.89	26′
28′	625.82	1244.2	34.07	28′
30′	627.50	1247.5	34.26	30′
32′	629.19	1250.9	34.44	32′
34′	630.87	1254.2	34.62	34′
36′	632.56	1257.5	34.80	36′
38′	634.24	1260.8	34.99	38′
40′	635.93	1264.1	35.18	40′
42′	637.62	1267.4	35.36	42′
44′	639.30	1270.7	35.55	44′
46′	640.99	1274.0	35.73	46′
48′	642.68	1277.3	35.92	48′
50′	644.37	1280.6	36.12	50′
52′	646.06	1284.0	36.31	52′
54′	647.75	1287.3	36.50	54′
56′	649.44	1290.6	36.69	56′
58′	651.13	1293.9	36.88	58′

Add 250.2 for Spiral No. 5.
" 450.6 " " " 9.

Add 250.3 for Spiral No. 5.
" 450.7 " " " 9.

Add 2.6 for Spiral No. 5.
" 7.3 " " " 9.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
13°	652.81		1297.2	37.07		**13°**
2′	654.50		1300.5	37.26		2′
4′	656.19		1303.8	37.45		4′
6′	657.88		1307.1	37.64		6′
8′	659.57		1310.4	37.83		8′
10′	661.25		1313.7	38.03		10′
12′	662.94		1317.0	38.22		12′
14′	664.63		1320.4	38.41		14′
16′	666.32		1323.7	38.60		16′
18′	668.01	Add 250.3 for Spiral No. 5. " 450.7 " " 9.	1327.0	38.80	Add 2.6 for Spiral No. 5. " 7.3 " " 9.	18′
20′	669.70		1330.3	39.00		20′
22′	671.39		1333.6	33.19		22′
24′	673.08		1336.9	39.39		24′
26′	674.77		1340.2	39.59		26′
28′	676.46		1343.5	39.79		28′
30′	678.15		1346.8	39.99		30′
32′	679.84		1350.2	40.19		32′
34′	681.53		1353.5	40.39		34′
36′	683.22		1356.8	40.59		36′
38′	684.91		1360.1	40.79		38′
40′	686.60		1363.4	40.99		40′
42′	688.29		1366.7	41.19		42′
44′	689.98		1370.0	41.39		44′
46′	691.67		1373.3	41.59		46′
48′	693.36		1376.6	41.80		48′
50′	695.05		1379.9	42.00		50′
52′	696.74		1383.3	42.20		52′
54′	698.43		1386.6	42.40		54′
56′	400.12		1389.9	42.61		56′
58′	401.81		1393.2	42.82		58′
14°	703.51		1396.5	43.03		**14°**
2′	705.20		1399.8	43.24		2′
4′	706.89	Add 250.3 for Spiral No. 5. " 450.8 " " 9. " 701.1 " " 14.	1403.1	43.44	Add 2.6 for Spiral No. 5. " 7.3 " " 9. " 16.3 " " 14.	4′
6′	708.58		1406.4	43.65		6′
8′	710.27		1409.7	43.86		8′
10′	711.97		1413.0	44.07		10′
12′	713.66		1416.4	44.27		12′
14′	715.36		1419.7	44.48		14′
16′	717.05		1423.0	44.70		16′
18′	718.74		1426.3	44.91		18′
20′	720.43		1429.6	45.12		20′
22′	722.12		1432.9	45.33		22′
24′	723.81		1436.2	45.54		24′
26′	725.50		1439.5	45.75		26′
28′	727.20		1442.8	45.97		28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance	Long Chord.	External Secant.	Whole Angle.
14° 30′	728.90	1446.1	46.18	**14°** 30′
32′	730.59	1449.5	46.40	32′
34′	732.28	1452.8	46.61	34′
36′	733.98	1456.1	46.83	36′
38′	735.67	1459.4	47.04	38′
40′	737.37	1462.7	47.25	40′
42′	739.06	1466.0	47.46	42′
44′	740.76	1469.3	47.68	44′
46′	742.45	1472.6	47.90	46′
48′	744.15	1475.9	48.12	48′
50′	745.84	1479.2	48.34	50′
52′	747.54	1482.5	48.56	52′
54′	749.23	1485.9	48.78	54′
56′	750.93	1489.2	49.00	56′
58′	752.62	1492.5	49.22	58′
15°	754.32	1495.8	49.44	**15°**
2′	756.02	1499.1	49.68	2′
4′	757.71	1502.4	49.90	4′
6′	759.40	1505.7	50.13	6′
8′	761.10	1509.0	50.34	8′
10′	762.80	1512.3	50.55	10′
12′	764.49	1515.6	50.77	12′
14′	766.18	1518.9	51.00	14′
16′	767.88	1522.2	51.23	16′
18′	769.58	1525.5	51.45	18′
20′	771.28	1528.8	51.67	20′
22′	772.98	1532.1	51.90	22′
24′	774.68	1535.4	52.14	24′
26′	776.37	1538.7	52.37	26′
28′	778.07	1542.0	52.60	28′
30′	779.77	1545.3	52.82	30′
32′	781.47	1548.6	53.05	32′
34′	783.17	1551.9	53.30	34′
36′	784.86	1555.2	53.53	36′
38′	786.56	1558.5	53.75	38′
40′	788.26	1561.8	53.97	40′
42′	789.96	1565.1	54.20	42′
44′	791.66	1568.4	54.43	44′
46′	793.35	1571.7	54.67	46′
48′	795.05	1575.0	54.90	48′
50′	796.75	1578.3	55.13	50′
52′	798.45	1581.6	55.36	52′
54′	800.15	1584.9	55.60	54′
56′	801.85	1588.2	55.84	56′
58′	803.55	1591.5	56.08	58′

Add 250.3 for Spiral No. 5:
" 450.8 " " 9:
" 701.3 " " 14:

Add 2.6 for Spiral No. 5:
" 7.3 " " 9:
" 16.4 " " 14:

IX.—FUNCTIONS OF A ONE-DEGREE CURVE

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
16 °	805.25	1594.8	56.31	**16°**
2′	806.95	1598.1	56.55	2′
4′	808.65	1601.4	56.80	4′
6′	810.35	1604.7	57.03	6′
8′	812.05	1608.0	57.27	8′
10′	813.75	1611.3	57.50	10′
12′	815.45	1614.6	57.74	12′
14′	817.15	1617.9	57.98	14′
16′	818.85	1621.2	58.22	16′
18′	820.55	1624.5	58.46	18′
20′	822.25	1627.8	58.70	20′
22′	823.95	1631.1	58.95	22′
24′	825.65	1634.4	59.20	24′
26′	827.35	1637.7	59.43	26′
28′	829.06	1641.0	59.67	28′
30′	830.76	1644.3	59.91	30′
32′	832.46	1647.6	60.16	32′
34′	834.16	1650.9	60.40	34′
36′	835.86	1654.2	60.65	36′
38′	837.56	1657.5	60.90	38′
40′	839.27	1660.8	61.14	40′
42′	840.97	1664.1	61.39	42′
44′	842.67	1667.4	61.64	44′
46′	844.37	1670.7	61.89	46′
48′	846.07	1674.0	62.14	48′
50′	847.78	1677.3	62.38	50′
52′	849.48	1680.6	62.63	52′
54′	851.18	1683.9	62.88	54′
56′	852.88	1687.2	63.13	56′
58′	854.59	1690.5	63.38	58′
17°	856.30	1693.8	63.63	**17°**
2′	858.00	1697.1	63.88	2′
4′	859.70	1700.4	64.13	4′
6′	861.41	1703.7	64.38	6′
8′	863.11	1707.0	64.64	8′
10′	864.82	1710.3	64.90	10′
12′	866.52	1713.6	65.16	12′
14′	868.23	1716.9	65.42	14′
16′	869.93	1710.2	65.68	16′
18′	871.64	1723.4	65.93	18′
20′	873.35	1726.7	66.18	20′
22′	875.05	1730.0	66.43	22′
24′	876.76	1733.3	66.68	24′
26′	878.46	1736.6	66.95	26′
28′	880.17	1739.9	67.23	28′

Add 701.4 for Spiral No. 14.

Add 250.4 for Spiral No. 5.
" 450.9 " " 9.

Add 701.5 for Spiral No. 14.

Add 2.6 for Spiral No. 5.
" 7.3 " " 9.
" 16.4 " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
17° 30′	881.88		1743.2	67.47		**17°** 30′
32′	883.58		1746.5	67.73		32′
34′	885.29	Add 450.9 for Spiral No. 9. " 701.6 " " " 14.	1749.8	68.00		34′
36′	886.99		1753.1	68.25		36′
38′	888.70		1756.4	68.50		38′
40′	890.41		1759.7	68.77		40′
42′	892.11		1763.0	69.03		42′
44′	893.82		1766.2	69.30		44′
46′	895.53		1769.5	69.56		46′
48′	897.24		1772.8	69.82		48′
50′	898.95		1776.1	70.09		50′
52′	900.66		1779.4	70.36		52′
54′	902.37		1782.7	70.63		54′
56′	904.08		1786.0	70.90		56′
58′	905.79		1789.3	71.17		58′
18°	907.49		1792.6	71.42		**18°**
2′	909.20		1795.9	71.68		2′
4′	910.91	Add 701.7 for Spiral No. 14.	1799.2	71.95		4′
6′	912.62		1802.5	72.22	Add 2.6 for Spiral No. 5. " 7.3 " " " 9. " 16.5 " " " 14.	6′
8′	914.33		1805.8	72.49		8′
10′	916.03		1809.1	72.76		10′
12′	917.74		1812.4	73.03		12′
14′	919.45		1815.7	73.30		14′
16′	921.16		1819.0	73.58		16′
18′	922.87		1822.2	73.86		18′
20′	924.58	Add 250.4 for Spiral No. 5. " 451.0 " " " 9.	1825.5	74.12		20′
22′	926.29		1828.8	74.40		22′
24′	928.00		1832.1	74.67		24′
26′	929.71		1835.4	74.94		26′
28′	931.42		1838.7	75.22		28′
30′	933.13		1842.0	75.49		30′
32′	934.84	Add 701.8 for Spiral No. 14.	1845.3	75.76		32′
34′	936.55		1848.6	76.03		34′
36′	938.26		1851.9	76.30		36′
38′	939.98		1855.2	76.58		38′
40′	941.69		1858.5	76.87		40′
42′	943.40		1861.8	77.15		42′
44′	945.11		1865.1	77.43		44′
46′	946.82		1868.4	77.70		46′
48′	948.53		1871.7	77.98		48′
50′	950.25		1875.0	78.26		50′
52′	951.96		1878.3	78.55		52′
54′	953.67		1881.6	78.84		54′
56′	955.39		1884.9	79.13		56′
58′	957.10		1888.2	79.40		58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
19°	958.81	1891.4	79.67	**19°**
2′	960.52	1894.7	79.95	2′
4′	962.23	1898.0	80.24	4′
6′	963.95	1901.2	80.52	6′
8′	965.67	1904.5	80.80	8′
10′	967.38	1907.8	81.09	10′
12′	969.10	1911.1	81.37	12′
14′	970.82	1914.4	81.66	14′
16′	972.53	1917.7	81.95	16′
18′	974.24	1921.0	82.23	18′
20′	975.95 Add 250.4 for Spiral No. 5. " 451.1 " " " 9. " 701.9 " " " 14.	1924.2	82.52	20′
22′	977.66	1927.5	82.80	22′
24′	979.38	1930.8	83.09	24′
26′	981.09	1934.0	83.38	26′
28′	982.81	1937.3	83.67	28′
30′	984.53	1940.6	83.97	30′
32′	986.24	1943.9	84.26	32′
34′	987.96	1947.2	84.55	34′
36′	989.67	1950.5	84.84 Add 2.6 for Spiral No. 5. " 7.3 " " " 9. " 16.5 " " " 14.	36′
38′	991.39	1953.8	85.13	38′
40′	993.11	1957.1	85.43	40′
42′	994.83	1960.4	85.72	42′
44′	996.55	1963.6	86.01	44′
46′	998.26	1966.9	86.30	46′
48′	999.98	1970.2	86.60	48′
50′	1001.70	1973.5	86.90	50′
52′	1003.42	1976.8	87.20	52′
54′	1005.13	1980.1	87.50	54′
56′	1006.85	1983.3	87.80	56′
58′	1008.56	1986.6	88.10	58′
20°	1010.3	1989.9	88.39	**20°**
2′	1012.1	1993.2	88.69	2′
4′	1013.8 Add 250.5 for Spiral No. 5. " 451.2 " " " 9. " 702.0 for Spiral No. 14.	1996.5	88.99	4′
6′	1015.5	1999.7	89.29	6′
8′	1017.3	2003.0	89.59	8′
10′	1018.9	2006.3	89.89	10′
12′	1020.6	2009.6	90.19	12′
14′	1022.3	2012.9	90.49	14′
16′	1024.0	2016.1	90.80	16′
18′	1025.7	2019.4	91.10	18′
20′	1027.5	2022.7	91.40	20′
22′	1029.2	2026.0	91.70	22′
24′	1031.0	2029.3	92.00	24′
26′	1032.7	2032.5	92.30	26′
28′	1034.4	2035.8	92.61	28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
20° 30′	1036.1	2039.1	92.92	**20°** 30′
32′	1037.8	2042.4	93.23	32′
34′	1039.5	2045.7	93.53	34′
36′	1041.3	2049.0	93.84	36′
38′	1043.0	2052.2	94.15	38′
40′	1044.7	2055.5	94.46	40′
42′	1046.3	2058.8	94.77	42′
44′	1048.0	2062.1	95.08	44′
46′	1049.7	2065.4	95.40	46′
48′	1051.5	2068.6	95.71	48′
50′	1053.3	2071.9	96.02	50′
52′	1055.0	2075.2	96.34	52′
54′	1056.7	2078.5	96.66	54′
56′	1058.4	2081.7	96.97	56′
58′	1060.2	2085.0	97.28	58′
21°	1061.9	2088.3	97.58	**21°**
2′	1063.6	2091.6	97.90	2′
4′	1065.3	2094.9	98.22	4′
6′	1067.0	2098.1	98.54	6′
8′	1068.8	2101.4	98.85	8′
10′	1070.5	2104.7	99.16	10′
12′	1072.2	2108.0	99.47	12′
14′	1073.9	2111.2	99.78	14′
16′	1075.7	2114.5	100.09	16′
18′	1077.4	2117.8	100.42	18′
20′	1079.1	2121.1	100.75	20′
22′	1080.8	2124.4	101.06	22′
24′	1082.5	2127.7	101.38	24′
26′	1084.3	2131.0	101.70	26′
28′	1086.0	2134.2	102.02	28′
30′	1087.8	2137.5	102.35	30′
32′	1089.5	2140.8	102.67	32′
34′	1091.2	2144.1	103.00	34′
36′	1093.0	2147.4	103.32	36′
38′	1094.7	2150.6	103.64	38′
40′	1096.4	2153.9	103.97	40′
42′	1098.1	2157.2	104.30	42′
44′	1099.9	2160.4	104.62	44′
46′	1101.6	2163.7	104.94	46′
48′	1103.3	2167.0	105.27	48′
50′	1105.1	2170.2	105.60	50′
52′	1106.9	2173.5	105.93	52′
54′	1108.6	2176.8	106.26	54′
56′	1110.3	2180.0	106.60	56′
58′	1112.0	2183.3	106.92	58′

Add 250.5 for Spiral No. 5.
" 451.2 " " " 9.
" 702.2 " " " 14.

Add 2.6 for Spiral No. 5.
" 7.3 " " " 9.
" 16.6 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
22°	1113.7	Add 702.3 for Spiral No. 14.	2186.6	107.2		22°
2′	1115.4		2189.9	107.5		2′
4′	1117.2		2193.2	107.9		4′
6′	1118.9		2196.4	108.2		6′
8′	1120.6		2199.7	108.6		8′
10′	1122.3		2202.9	108.9		10′
12′	1124.0		2206.2	109.3		12′
14′	1125.8		2209.5	109.6		14′
16′	1127.5		2212.7	110.0		16′
18′	1129.2		2216.0	110.3		18′
20′	1131.0		2219.3	110.6		20′
22′	1132.7		2222.6	110.9		22′
24′	1134.5		2225.8	111.3		24′
26′	1136.2		2229.1	111.6		26′
28′	1138.0		2232.4	112.0		28′
30′	1139.7	Add 250.5 for Spiral No. 5. " 451.4 " " " 9. " 702.5 " " " 14.	2235.6	112.3	Add 2.6 for Spiral No. 5. " 7.4 " " " 9. " 16.6 " " " 14.	30′
32′	1141.3		2238.9	112.6		32′
34′	1143.0		2242.1	113.0		34′
36′	1144.8		2245.4	113.3		36′
38′	1146.6		2248.7	113.7		38′
40′	1148.4		2252.0	114.0		40′
42′	1150.1		2255.3	114.3		42′
44′	1151.8		2258.5	114.6		44′
46′	1153.6		2261.8	115.0		46′
48′	1155.3		2265.1	115.3		48′
50′	1157.0		2268.3	115.7		50′
52′	1158.8		2271.6	116.0		52′
54′	1160.5		2274.9	116.4		54′
56′	1162.3		2278.2	116.7		56′
58′	1164.0		2281.5	117.0		58′
23°	1165.7	Add 702.4 for Spiral No. 14.	2284.7	117.4		23°
2′	1167.4		2288.0	117.7		2′
4′	1179.1		2291.2	118.1		4′
6′	1180.9		2294.5	118.4		6′
8′	1182.6		2297.7	118.7		8′
10′	1174.3		2301.0	119.1		10′
12′	1176.0		2304.3	119.4		12′
14′	1177.8		2307.5	119.7		14′
16′	1179.6		2310.8	120.1		16′
18′	1181.3		2314.0	120.5		18′
20′	1183.0		2317.3	120.9		20′
22′	1184.8		2320.6	121.2		22′
24′	1186.5		2323.8	121.6		24′
26′	1188.3		2327.1	121.9		26′
28′	1190.0		2330.4	122.3		28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
23° 30′	1191.7	2333.6	122.6	**23°** 30′
32′	1193.5	2336.9	123.0	32′
34′	1195.2	2340.2	123.3	34′
36′	1197.0	2343.5	123.7	36′
38′	1198.7	2346.7	124.0	38′
40′	1200.4	2349.9	124.4	40′
42′	1202.2	2353.2	124.7	42′
44′	1203.9	2356.4	125.0	44′
46′	1205.7	2359.7	125.4	46′
48′	1207.4	2363.0	125.8	48′
50′	1209.1	2366.2	126.2	50′
52′	1210.9	2369.5	126.5	52′
54′	1212.6	2372.7	126.9	54′
56′	1214.4	2376.0	127.2	56′
58′	1216.1	2379.2	127.6	58′
24°	1217.9	2382.5	128.0	**24°**
2′	1219.6	2385.8	128.3	2′
4′	1221.4	2389.1	128.7	4′
6′	1223.1	2392.3	129.0	6′
8′	1224.9	2395.6	129.4	8′
10′	1226.6	2398.8	129.8	10′
12′	1228.3	2402.1	130.1	12′
14′	1230.1	2405.3	130.5	14′
16′	1231.8	2408.6	130.8	16′
18′	1233.5	2411.8	131.2	18′
20′	1235.3	2415.1	131.6	20′
22′	1237.0	2418.4	132.0	22′
24′	1238.8	2421.6	132.3	24′
26′	1240.5	2424.9	132.7	26′
28′	1242.2	2428.1	133.1	28′
30′	1244.0	2431.4	133.5	30′
32′	1245.7	2434.7	133.8	32′
34′	1247.5	2437.9	134.2	34′
36′	1249.3	2441.2	134.6	36′
38′	1251.0	2444.4	135.0	38′
40′	1252.7	2447.7	135.4	40′
42′	1254.5	2451.0	135.8	42′
44′	1256.3	2454.2	136.2	44′
46′	1258.0	2457.5	136.5	46′
48′	1259.7	2460.8	136.9	48′
50′	1261.4	2464.0	137.2	50′
52′	1263.2	2467.3	137.6	52′
54′	1265.0	2470.5	138.0	54′
56′	1266.7	2473.8	138.3	56′
58′	1268.5	2477.0	138.7	58′

Add 702.6 for Spiral No. 14.

Add 250.5 for Spiral No. 5.
" 451.4 " " " 9.

Add 702.7 for Spiral No. 14.

Add 2.6 for Spiral No. 5.
" 7.4 " " " 9.
" 16.7 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
25°	1270.2	2480.2	139.1	**25°**
2′	1272.0	2483.5	139.5	2′
4′	1273.7	2486.7	139.9	4′
6′	1275.5	2490.0	140.2	6′
8′	1277.2	2493.2	140.6	8′
10′	1278.9	2496.4	141.0	10′
12′	1280.7	2499.7	141.4	12′
14′	1282.4	2502.9	141.8	14′
16′	1284.2	2506.2	142.2	16′
18′	1286.0	2509.5	142.6	18′
20′	1287.7 Add 250.5 for Spiral No. 5. " 451.5 " " " 9. " 702.8 " " " 14.	2512.7	142.9	20′
22′	1289.5	2516.0	143.3	22′
24′	1291.2	2519.2	143.7	24′
26′	1293.0	2522.5	144.0	26′
28′	1294.8	2525.8	144.4	28′
30′	1296.5	2529.0	144.8	30′
32′	1298.3	2532.3	145.2	32′
34′	1300.0	2535.5	145.6	34′
36′	1301.8	2538.8	146.0 Add 2.6 for Spiral No. 5. " 7.4 " " " 9. " 16.7 " " " 14.	36′
38′	1303.5	2542.0	146.4	38′
40′	1305.2	2545.2	146.8	40′
42′	1307.0	2548.5	147.2	42′
44′	1308.7	2551.7	147.6	44′
46′	1310.5	2555.0	148.0	46′
48′	1312.2	2558.2	148.4	48′
50′	1314.0	2561.4	148.8	50′
52′	1315.7	2564.7	149.2	52′
54′	1317.5	2567.9	149.6	54′
56′	1319.2	2571.2	150.0	56′
58′	1321.0	2574.4	150.4	58′
26°	1322.8	2577.7	150.7	**26°**
2′	1324.5 Add 250.6 for Spiral No. 5. " 451.6 " " " 9. " 702.9 " " " 14.	2581.0	151.1	2′
4′	1326.3	2584.2	151.5	4′
6′	1328.1	2587.5	151.9	6′
8′	1329.8	2590.7	152.3	8′
10′	1331.5	2593.9	152.7	10′
12′	1333.2	2597.2	153.1	12′
14′	1335.0	2600.4	153.5	14′
16′	1336.7	2603.7	153.9	16′
18′	1338.5	2607.0	154.3	18′
20′	1340.3	2610.2	154.7	20′
22′	1342.0	2613.5	155.1	22′
24′	1343.8	2616.8	155.5	24′
26′	1345.6	2620.0	155.9	26′
28′	1347.4	2623.2	156.3	28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
26° 30′	1349.1	2626.4	156.7	**26°** 30′
32′	1350.9	2629.7	157.1	32′
34′	1352.7	2632.9	157.5	34′
36′	1354.4	2636.1	157.9	36′
38′	1356.2	2639.4	158.3	38′
40′	1357.9	2642.6	158.7	40′
42′	1359.7	2645.9	159.1	42′
44′	1361.5	2649.1	159.5	44′
46′	1363.2	2652.4	160.0	46′
48′	1365.0	2655.6	160.4	48′
50′	1366.7	2658.9	160.8	50′
52′	1368.5	2662.2	161.2	52′
54′	1370.2	2665.4	161.6	54′
56′	1372.0	2668.7	162.0	56′
58′	1373.8	2671.9	162.4	58′
27°	1375.5	2675.1	162.8	**27°**
2′	1377.3	2678.4	163.2	2′
4′	1379.0	2681.6	163.6	4′
6′	1380.8	2684.9	164.0	6′
8′	1382.6	2688.1	164.5	8′
10′	1384.4	2691.3	164.9	10′
12′	1386.2	2694.6	165.3	12′
14′	1388.0	2697.8	165.7	14′
16′	1389.7	2701.1	166.1	16′
18′	1391.5	2704.3	166.5	18′
20′	1393.2	2707.5	166.9	20′
22′	1395.0	2710.8	167.4	22′
24′	1396.7	2714.0	167.8	24′
26′	1398.5	2717.2	168.2	26′
28′	1400.3	2720.4	168.6	28′
30′	1402.0	2723.6	169.0	30′
32′	1403.8	2726.8	169.4	32′
34′	1405.6	2730.0	169.8	34′
36′	1407.3	2733.3	170.3	36′
38′	1409.1	2736.5	170.7	38′
40′	1410.8	2739.8	171.1	40′
42′	1412.6	2743.0	171.6	42′
44′	1414.4	2746.3	172.0	44′
46′	1416.1	2749.5	172.4	46′
48′	1417.8	2752.7	172.9	48′
50′	1419.6	2756.0	173.3	50′
52′	1421.4	2759.2	173.7	52′
54′	1423.1	2762.5	174.2	54′
56′	1424.9	2765.8	174.6	56′
58′	1426.7	2769.0	175.0	58′

Add 703.0 for Spiral No. 14.

Add 250.6 for Spiral No. 5.
" 451.6 " " " 9.

Add 703.1 for Spiral No. 14.

Add 2.6 for Spiral No. 5.
" 7.4 " " " 9.
" 16.8 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
28°	1428.5	2772.2	175.4	**28°**
2′	1430.3	2775.5	175.8	2′
4′	1432.0	2778.7	176.3	4′
6′	1433.8	2782.0	176.7	6′
8′	1435.6	2785.2	177.2	8′
10′	1437.4	2788.4	177.6	10′
12′	1439.2	2791.7	178.0	12′
14′	1441.0	2794.9	178.5	14′
16′	1442.7	2798.1	178.9	16′
18′	1444.5	2801.3	179.3	18′
20′	1446.2	2804.5	179.7	20′
22′	1448.0	2807.8	180.2	22′
24′	1449.7	2811.0	180.6	24′
26′	1451.5	2814.2	181.0	26′
28′	1453.3	2817.5	181.5	28′
30′	1455.1	2820.7	181.9	30′
32′	1456.9	2824.0	182.3	32′
34′	1458.7	2827.2	182.8	34′
36′	1460.5	2830.5	183.2	36′
38′	1462.3	2833.7	183.7	38′
40′	1464.0	2836.9	184.1	40′
42′	1465.8	2840.2	184.6	42′
44′	1467.6	2843.4	185.0	44′
46′	1469.3	2846.6	185.4	46′
48′	1471.1	2849.8	185.9	48′
50′	1472.9	2853.0	186.3	50′
52′	1474.7	2856.3	186.7	52′
54′	1476.5	2859.5	187.2	54′
56′	1478.3	2862.7	187.6	56′
58′	1480.0	2866.0	188.1	58′
29°	1481.8	2869.2	188.5	**29°**
2′	1483.6	2872.5	189.0	2′
4′	1485.4	2875.7	189.4	4′
6′	1487.1	2878.9	189.9	6′
8′	1488.9	2882.1	190.3	8′
10′	1490.7	2885.3	190.7	10′
12′	1492.5	2888.5	191.2	12′
14′	1494.3	2891.8	191.6	14′
16′	1496.0	2895.0	192.1	16′
18′	1497.8	2898.2	192.5	18′
20′	1499.6	2901.4	193.0	20′
22′	1501.4	2904.6	193.5	22′
24′	1503.2	2907.9	193.9	24′
26′	1505.0	2911.1	194.4	26′
28′	1506.7	2914.3	194.8	28′

Add 703.2 for Spiral No. 14.

Add 250.6 for Spiral No. 5.
" 451.8 " " " 9.

Add 703.3 for Spiral No. 14.

Add 2.6 for Spiral No. 5.
" 7.4 " " " 9.
" 16.8 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
29° 30′	1508.5		2917.5	195.3		**29°** 30′
32′	1510.3		2920.8	195.7		32′
34′	1512.0		2924.0	196.2		34′
36′	1513.8		2927.2	196.6		36′
38′	1515.6	Add 250.6 for Spiral No. 5. " 451.8 " " 9. " 703.4 " " 14.	2930.5	197.1		38′
40′	1517.4		2933.7	197.5		40′
42′	1519.2		2937.0	198.0		42′
44′	1521.0		2940.2	198.4		44′
46′	1522.7		2943.4	198.9		46′
48′	1524.5		2946.6	199.3		48′
50′	1526.3		2949.8	199.8		50′
52′	1528.0		2953.0	200.2		52′
54′	1529.8		2956.3	200.7		54′
56′	1531.6		2959.5	201.1		56′
58′	1533.4		2962.7	201.6		58′
30°	1535.2		2965.9	202.1		**30°**
2′	1537.0		2969.1	202.6		2′
4′	1538.8		2972.3	203.0	Add 2.6 for Spiral No. 5. " 7.4 " " 9. " 16.9 " " 14.	4′
6′	1540.6		2975.6	203.5		6′
8′	1542.4	Add 703.5 for Spiral No. 14.	2978.8	203.9		8′
10′	1544.2		2982.0	204.4		10′
12′	1546.0		2985.3	204.9		12′
14′	1547.8		2988.5	205.3		14′
16′	1549.6		2991.7	205.8		16′
18′	1551.4		2994.9	206.3		18′
20′	1553.2	Add 250.7 for Spiral No. 5. " 451.8 " " 9.	2998.1	206.8		20′
22′	1554.9		3001.3	207.2		22′
24′	1556.7		3004.5	207.7		24′
26′	1558.5		3007.7	208.1		26′
28′	1560.3		3010.9	208.6		28′
30′	1562.1		3014.1	209.1		30′
32′	1563.9		3017.3	209.5		32′
34′	1565.7		3020.5	210.0		34′
36′	1567.4		3023.8	210.5		36′
38′	1569.2		3027.0	211.0		38′
40′	1571.0	Add 703.6 for Spiral No. 14.	3030.2	211.5		40′
42′	1572.8		3033.4	212.0		42′
44′	1574.6		3036.6	212.4		44′
46′	1576.4		3039.9	212.9		46′
48′	1578.2		3043.1	213.4		48′
50′	1580.0		3046.3	213.9		50′
52′	1581.8		3049.5	214.4		52′
54′	1583.6		3052.8	214.8		54′
56′	1585.4		3056.0	215.3		56′
58′	1587.2		3059.2	215.8		58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Agnle.
31°	1588.9	3062.4	216.3	**31°**
2′	1590.7	3065.6	216.8	2′
4′	1592.5	3068.8	217.3	4′
6′	1594.3	3072.0	217.7	6′
8′	1596.1	3075.2	218.2	8′
10′	1597.9	3078.4	218.7	10′
12′	1599.7	3081.6	219.1	12′
14′	1601.5	3084.8	219.6	14′
16′	1603.3	3088.0	220.1	16′
18′	1605.1	3091.3	220.6	18′
20′	1606.9	3094.5	221.1	20′
22′	1608.7	3097.7	221.6	22′
24′	1610.5	3100.9	222.1	24′
26′	1612.3	3104.1	222.5	26′
28′	1614.1	3107.3	223.0	28′
30′	1615.9	3110.5	223.5	30′
32′	1617.7	3113.7	224.0	32′
34′	1619.5	3116.9	224.5	34′
36′	1621.3	3120.1	225.0	36′
38′	1623.1	3123.3	225.5	38′
40′	1624.9	3126.5	226.0	40′
42′	1626.7	3129.7	226.5	42′
44′	1628.5	3132.9	227.0	44′
46′	1630.3	3136.2	227.5	46′
48′	1632.1	3139.4	228.0	48′
50′	1633.9	3142.6	228.4	50′
52′	1635.7	3145.8	228.9	52′
54′	1637.5	3149.0	229.4	54′
56′	1639.3	3152.2	229.9	56′
58′	1641.1	3155.4	230.4	58′
32°	1642.9	3158.6	230.9	**32°**
2′	1644.7	3161.8	231.4	2′
4′	1646.5	3165.0	231.9	4′
6′	1468.3	3168.2	232.4	6′
8′	1650.1	3171.4	332.9	8′
10′	1651.9	3174.6	233.4	10′
12′	1653.7	3177.8	233.9	12′
14′	1655.5	3181.0	234.4	14′
16′	1657.3	3184.2	234.9	16′
18′	1659.1	3187.4	235.4	18′
20′	1660.9	3190.6	235.9	20′
22′	1662.7	3193.8	236.4	22′
24′	1664.5	3197.0	236.9	24′
26′	1666.3	3200.2	237.4	26′
28′	1668.1	3203.4	237.9	28′

Tangent Distance:
Add 250.7 for Spiral No. 5.
" 451.9 " " 9.
" 703.7 " " 14.

External Secant:
Add 2.6 for Spiral No. 5.
" 7.5 " " 9.
" 16.9 " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
32° 30′	1669.9	3206.6	238.4	**32°** 30′
32′	1671.7	3209.8	238.9	32′
34′	1673.5	3213.0	239.4	34′
36′	1675.3	3216.2	239.9	36′
38′	1677.1	3219.4	240.5	38′
40′	1679.0	3222.6	241.0	40′
42′	1680.8	3225.8	241.5	42′
44′	1682.6	3229.0	242.0	44′
46′	1684.4	3232.2	242.5	46′
48′	1686.2	3235.4	243.0	48′
50′	1688.1	3238.6	243.5	50′
52′	1689.9	3241.8	244.0	52′
54′	1691.7	3245.0	244.6	54′
56′	1693.5	3248.2	245.1	56′
58′	1695.3	3251.4	245.6	58′
33°	1697.2	3254.6	246.1	**33°**
2′	1699.0	3257.8	246.6	2′
4′	1700.8	3261.0	247.2	4′
6′	1702.7	3264.2	247.7	6′
8′	1704.5	3267.4	248.2	8′
10′	1706.3	3270.6	248.7	10′
12′	1708.1	3273.8	249.2	12′
14′	1709.9	3277.0	249.7	14′
16′	1711.7	3280.2	250.3	16′
18′	1713.5	3283.4	250.8	18′
20′	1715.3	3286.6	251.3	20′
22′	1717.1	3289.8	251.8	22′
24′	1718.9	3293.0	252.3	24′
26′	1720.8	3296.2	252.8	26′
28′	1722.6	3299.3	253.3	28′
30′	1724.4	3302.5	253.9	30′
32′	1726.2	3305.7	254.4	32′
34′	1728.0	3308.9	255.0	34′
36′	1729.9	3312.1	255.5	36′
38′	1731.7	3315.3	256.0	38′
40′	1733.5	3318.5	256.5	40′
42′	1735.3	3321.7	257.0	42′
44′	1737.2	3324.9	257.5	44′
46′	1739.0	3328.1	258.0	46′
48′	1740.8	3331.2	258.5	48′
50′	1742.6	3334.4	259.1	50′
52′	1744.4	3337.6	259.6	52′
54′	1746.2	3340.8	260.2	54′
56′	1748.0	3344.0	260.7	56′
58′	1749.9	3347.2	261.3	58′

Add 250.7 for Spiral No. 5.
" 452.0 " " 9.
" 704.0 " " 14.

Add 2.7 for Spiral No. 5.
" 7.5 " " 9.
" 17.0 " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
34°	1751.7	Add 704.1 for Spiral No. 14.	3350.4	261.8		**34°**
2′	1753.6		3353.6	262.4		2′
4′	1755.4		3356.8	262.9		4′
6′	1757.2		3360.0	263.5		6′
8′	1759.0		3363.1	264.0		8′
10′	1760.8		3366.3	264.5		10′
12′	1762.7		3369.5	265.1		12′
14′	1764.5		3372.7	265.6		14′
16′	1766.3		3375.9	266.2		16′
18′	1768.1		3379.0	266.7		18′
20′	1769.9		3382.2	267.2		20′
22′	1771.7		3385.4	267.8		22′
24′	1773.6		3388.6	268.3		24′
26′	1775.4		3391.8	268.9		26′
28′	1777.2		3395.0	269.4		28′
30′	1779.0	Add 250.8 for Spiral No. 5. " 452.2 " " 9. " 704.2 " " 14.	3398.1	269.9	Add 2.7 for Spiral No. 5. " 7.6 " " 9. " 17.1 " " 14.	30′
32′	1780.9		3401.3	270.5		32′
34′	1782.7		3404.5	270.0		34′
36′	1784.5		3407.7	271.6		36′
38′	1786.3		3410.9	272.1		38′
40′	1788.2		3414.0	272.6		40′
42′	1790.1		3417.2	273.2		42′
44′	1791.9		3420.4	273.7		44′
46′	1793.7		3423.5	274.3		46′
48′	1795.6		3426.7	274.8		48′
50′	1797.4		3429.9	275.3		50′
52′	1799.2		3433.1	275.9		52′
54′	1801.1		3436.3	276.4		54′
56′	1803.0		3439.4	277.0		56′
58′	1804.8		3442.6	277.5		58′
35°	1806.6	Add 704.3 for Spiral No. 14.	3445.8	278.1		**35°**
2′	1808.5		3449.0	278.6		2′
4′	1810.3		3452.1	279.2		4′
6′	1812.1		3455.3	279.7		6′
8′	1813.9		3458.5	280.2		8′
10′	1815.7		3461.7	280.8		10′
12′	1817.6		3464.9	281.3		12′
14′	1819.4		3468.0	281.9		14′
16′	1821.3		3471.2	282.4		16′
18′	1823.1		3474.4	283.0		18′
20′	1824.9		3477.6	283.6		20′
22′	1826.8		3480.8	284.1		22′
24′	1828.6		3484.0	284.7		24′
26′	1830.4		3487.1	285.2		26′
28′	1832.3		3490.3	285.8		28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
35° 30′	1834.1		3493.5	286.4		**35°** 30′
32′	1836.0		3496.6	286.9		32′
34′	1837.8	Add 704.3 for Spiral No. 14.	3499.8	287.5		34′
36′	1839.7		3503.0	288.0		36′
38′	1841.5		3506.2	288.6		38′
40′	1843.3		3509.3	289.2		40′
42′	1845.2		3512.5	289.7		42′
44′	1847.0		3515.6	290.3		44′
46′	1848.9		3518.8	290.8		46′
48′	1850.7		3522.0	291.4		48′
50′	1852.5		3525.2	292.0		50′
52′	1854.3		3528.4	292.6		52′
54′	1856.2		3531.5	293.1		54′
56′	1858.0		3534.7	293.7		56′
58′	1859.9		3537.9	294.3		58′
36°	1861.7		3541.1	294.9		**36°**
2′	1863.6		3544.3	295.5		2′
4′	1865.4	Add 704.4 for Spiral No. 14.	3547.4	296.0		4′
6′	1867.3		3550.6	296.6	Add 2.7 for Spiral No. 5. " 7.6 " " 9. " 17.1 " " 14.	6′
8′	1869.2		3553.8	297.1		8′
10′	1870.9		3557.0	297.7		10′
12′	1872.8		3560.2	298.3		12′
14′	1874.6		3563.3	298.8		14′
16′	1876.4		3566.5	299.4		16′
18′	1878.3		3569.6	300.0		18′
20′	1880.1	Add 250.8 for Spiral No. 5. " 452.2 " " 9.	3572.8	300.6		20′
22′	1882.0		3576.0	301.2		22′
24′	1883.8		3579.1	301.7		24′
26′	1885.7		3582.3	302.3		26′
28′	1887.5		3585.5	302.9		28′
30′	1889.3		3588.6	303.5		30′
32′	1891.2		3591.8	304.0		32′
34′	1893.0	Add 704.5 for Spiral No. 14.	3594.9	304.6		34′
36′	1894.8		3598.1	305.2		36′
38′	1896.7		3601.3	305.8		38′
40′	1898.5		3604.4	306.4		40′
42′	1900.4		3607.6	307.0		42′
44′	1902.2		3610.7	307.5		44′
46′	1904.1		3613.9	308.1		46′
48′	1905.9		3617.1	308.7		48′
50′	1907.8		3620.2	309.3		50′
52′	1909.6		3623.4	309.9		52′
54′	1911.5		3626.5	310.4		54′
56′	1913.3		3629.7	311.0		56′
58′	1915.2		3632.8	311.6		58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
37°	1917.1		3636.0	312.2		**37°**
2′	1919.0		3639.1	312.8		2′
4′	1920.8	Add 704.6 for Spiral No. 14.	3642.3	313.4		4′
6′	1922.7		3645.5	314.0		6′
8′	1904.5		3648.6	314.6		8′
10′	1926.4		3651.8	315.2		10′
12′	1928.3		3654.9	315.8		12′
14′	1930.1		3658.1	316.4		14′
16′	1932.0		3661.3	317.0		16′
18′	1933.8		3664.5	317.6		18′
20′	1935.7	Add 250.8 for Spiral No. 5. " 452.3 " " " 9.	3667.6	318.1		20′
22′	1937.6		3670.8	318.7		22′
24′	1939.4		3673.9	319.3		24′
26′	1941.3		3677.1	319.9		26′
28′	1943.1		3680.2	320.5		28′
30′	1945.0		3683.3	321.1		30′
32′	1946.9	Add 704.7 for Spiral No. 14.	3686.5	321.7		32′
34′	1948.7		3689.6	322.3		34′
36′	1950.6		3692.8	322.9	Add 2.7 for Spiral No. 5. " 7.6 " " " 9. " 17.2 " " " 14.	36′
38′	1952.4		3695.9	323.5		38′
40′	1954.3		3699.1	324.1		40′
42′	1956.2		3702.2	324.7		42′
44′	1958.0		3705.5	325.3		44′
46′	1959.9		3708.6	325.9		46′
48′	1961.7		3711.8	326.5		48′
50′	1963.6		3714.9	327.1		50′
52′	1965.5		3718.0	327.7		52′
54′	1967.3		3721.2	328.3		54′
56′	1969.2		3724.5	328.9		56′
58′	1971.0		3727.6	329.5		58′
38°	1972.9		3730.7	330.2		**38°**
2′	1974.8		3733.8	330.8		2′
4′	1976.6	Add 250.9 for Spiral No. 5. " 452.4 " " " 9. " 704.8 " " " 14.	3737.0	331.4		4′
6′	1978.5		3740.1	332.0		6′
8′	1980.3		3743.3	332.6		8′
10′	1982.2		3746.4	333.2		10′
12′	1984.0		3749.5	333.8		12′
14′	1985.9		3752.7	334.5		14′
16′	1987.7		3755.8	335.1		16′
18′	1989.6		3759.0	335.7		18′
20′	1991.5		3762.2	336.3		20′
22′	1993.4		3765.3	336.9		22′
24′	1995.3		3768.5	337.5		24′
26′	1997.1		3771.6	338.1		26′
28′	1999.0		3774.8	338.7		28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
38° 30′	2000.8	Add 704.8 for Spiral No. 14.	3777.9	339.3		**38°** 30′
32′	2002.7		3781.1	339.9		32′
34′	2004.5		3784.2	340.6		34′
36′	2006.4		3787.4	341.2		36′
38′	2008.3		3790.5	341.8		38′
40′	2010.2		3793.7	342.4		40′
42′	2012.1		3796.8	343.0		42′
44′	2014.0		3800.0	343.7		44′
46′	2015.8		3803.1	344.3		46′
48′	2017.7		3806.2	344.9		48′
50′	2019.6		3809.4	345.5		50′
52′	2021.5		3812.5	346.1		52′
54′	2023.4		3815.7	346.8		54′
56′	2025.3		3818.9	347.4		56′
58′	2027.2		3822.0	348.0		58′
39°	2029.0		3825.1	348.6		**39°**
2′	2030.9		3828.2	349.3		2′
4′	2032.8	Add 250.9 for Spiral No. 5. " 452.4 " " " 9. " 704.9 " " " 14.	3831.4	349.9	Add 2.7 for Spiral No. 5. " 7.7 " " " 9. " 17.3 " " " 14.	4′
6′	2034.7		3834.5	350.5		6′
8′	2036.6		3837.7	351.2		8′
10′	2038.4		3840.8	351.8		10′
12′	2040.3		3843.9	352.4		12′
14′	2042.2		3847.1	353.1		14′
16′	2044.1		3850.2	353.7		16′
18′	2046.0		3853.4	354.3		18′
20′	2047.8		3856.5	354.9		20′
22′	2049.7		3859.6	355.5		22′
24′	2051.6		3862.8	356.2		24′
26′	2053.5		3865.9	356.8		26′
28′	2055.4		3869.1	357.5		28′
30′	2057.2	Add 705.0 for Spiral No. 14.	3872.2	358.1		30′
32′	2059.1		3875.3	358.7		32′
34′	2061.0		3878.5	359.4		34′
36′	2062.9		3881.6	360.0		36′
38′	2064.8		3884.7	360.7		38′
40′	2066.6		3887.9	361.3		40′
42′	2068.5		3891.0	362.0		42′
44′	2070.4		3894.2	362.6		44′
46′	2072.3		3897.3	363.3		46′
48′	2074.2		3900.4	363.9		48′
50′	2076.0		3903.5	364.5		50′
52′	2077.9		3906.6	365.2		52′
54′	2079.8		3909.8	365.8		54′
56′	2081.7		3912.9	366.5		56′
58′	2083.6		3916.0	367.1		58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
40°	2085.4	3919.2	367.7	**40°**
2′	2087.3	3922.3	368.4	2′
4′	2089.2	3925.5	369.0	4′
6′	2091.1	3928.6	369.7	6′
8′	2093.0	3931.7	370.3	8′
10′	2094.9	3934.8	371.0	10′
12′	2096.8	3937.9	371.6	12′
14′	2098.7	3941.0	372.3	14′
16′	2100.6	3944.2	372.9	16′
18′	2102.5	3947.3	373.6	18′
20′	2104.3	3950.5	374.2	20′
22′	2106.2	3953.6	374.9	22′
24′	2108.1	3956.8	375.5	24′
26′	2110.0	3959.9	376.2	26′
28′	2111.9	3963.0	376.8	28′
30′	2113.7	3966.1	377.5	30′
32′	2115.6	3969.2	378.1	32′
34′	2117.5	3972.4	378.8	34′
36′	2119.4	3975.5	379.4	36′
38′	2121.3	3978.6	380.1	38′
40′	2123.2	3981.8	380.8	40′
42′	2125.1	3984.9	381.4	42′
44′	2127.0	3988.1	382.1	44′
46′	2128.9	3991.2	382.7	46′
48′	2130.8	3994.3	383.4	48′
50′	2132.7	3997.4	384.1	50′
52′	2134.6	4000.5	384.7	52′
54′	2136.5	4003.7	385.4	54′
56′	2138.4	4006.8	386.0	56′
58′	2140.3	4009.9	386.7	58′
41°	2142.2	4013.1	387.4	**41°**
2	2144.1	4016.2	388.1	2′
4′	2146.0	4019.3	388.7	4′
6′	2147.9	4022.5	389.4	6′
8′	2149.8	4025.6	390.0	8′
10′	2151.7	4028.7	390.7	10′
12′	2153.6	4031.8	391.4	12′
14′	2155.5	4034.9	392.0	14′
16′	2157.4	4038.0	392.7	16′
18′	2159.3	4041.2	393.4	18′
20′	2161.2	4044.3	394.1	20′
22′	2163.1	4047.4	394.8	22′
24′	2165.0	4050.5	395.4	24′
26′	2166.9	4053.6	396.1	26′
28′	2168.8	4056.7	396.7	28′

Add 705.1 for Spiral No. 14.

Add 250.9 for Spiral No. 5.
" 452.5 " " " 9.

Add 705.2 for Spiral No. 14.

Add 2.7 for Spiral No. 5.
" 7.7 " " " 9.
" 17.3 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
41° 30′	2170.7	4059.8	397.4	**41°** 30′
32′	2172.6	4062.9	398.1	32′
34′	2174.5	4066.0	398.8	34′
36′	2176.4	4069.2	399.5	36′
38′	2178.3	4072.3	400.2	38′
40′	2180.3	4075.4	400.9	40′
42′	2182.2	4078.5	401.6	42′
44′	2184.1	4081.6	402.2	44′
46′	2186.0	4084.7	402.9	46′
48′	2188.0	4087.9	403.6	48′
50′	2189.9	4091.0	404.3	50′
52′	2191.8	4094.1	405.0	52′
54′	2193.7	4097.2	405.6	54′
56′	2195.6	4100.3	406.3	56′
58′	2197.5	4103.4	407.0	58′
42°	2199.4	4106.6	407.7	**42°**
2′	2201.3	4109.7	408.4	2′
4′	2203.3	4112.8	409.0	4′
6′	2205.2	4115.9	409.7	6′
8′	2207.1	4119.0	410.4	8′
10′	2209.0	4122.1	411.1	10′
12′	2210.9	4125.2	411.8	12′
14′	2212.9	4128.3	412.5	14′
16′	2214.8	4131.4	413.1	16′
18′	2216.7	4134.5	413.8	18′
20′	2218.6	4137.7	414.5	20′
22′	2220.5	4140.8	415.2	22′
24′	2222.5	4143.9	415.9	24′
26′	2224.4	4147.0	416.6	26′
28′	2226.3	4150.1	417.3	28′
30′	2228.2	4153.2	418.0	30′
32′	2230.2	4156.3	418.7	32′
34′	2232.1	4159.4	419.4	34′
36′	2234.0	4162.5	420.1	36′
38′	2235.9	4165.6	420.8	38′
40′	2237.8	4168.7	421.5	40′
42′	2239.8	4171.8	422.2	42′
44′	2241.7	4174.9	422.9	44′
46′	2243.6	4178.0	423.6	46′
48′	2245.5	4181.1	424.3	48′
50′	2247.4	4184.3	425.0	50′
52′	2249.4	4187.4	425.7	52′
54′	2251.3	4190.5	426.4	54′
56′	2253.2	4193.6	427.1	56′
58′	2255.1	4196.7	427.8	58′

Add 705.4 for Spiral No. 14.

Add 251.0 for Spiral No. 5.
" 452.6 " " 9.

Add 705.5 for Spiral No. 14.

Add 2.7 for Spiral No. 5.
" 7.7 " " 9.
" 17.4 " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
43°	2257.0	4199.8	428.5	**43°**
2′	2259.0	4202.9	429.2	2′
4′	2260.9	4206.0	429.9	4′
6′	2262.8	4209.1	430.6	6′
8′	2264.7	4212.2	431.3	8′
10′	2266.6	4215.3	432.0	10′
12′	2268.6	4218.4	432.7	12′
14′	2270.5	4221.5	433.5	14′
16′	2272.4	4224.6	434.2	16′
18′	2274.3	4227.7	434.9	18′
20′	2276.2	4230.8	435.6	20′
22′	2278.2	4333.9	436.3	22′
24′	2280.1	4237.0	437.0	24′
26′	2282.0	4240.1	437.8	26′
28′	2283.9	4243.2	438.5	28′
30′	2285.8	4246.2	439.2	30′
32′	2287.7	4249.3	439.9	32′
34′	2289.6	4252.4	440.7	34′
36′	2291.5	4255.5	441.4	36′
38′	2293.4	4258.6	442.1	38′
40′	2295.5	4261.7	442.8	40′
42′	2297.6	4264.8	443.5	42′
44′	2299.5	4267.9	444.2	44′
46′	2301.4	4271.0	445.0	46′
48′	2303.3	4274.1	445.7	48′
50′	2305.2	4277.2	446.4	50′
52′	2307.2	4280.3	447.1	52′
54′	2309.1	4283.4	447.8	54′
56′	2311.0	4286.5	448.6	56′
58′	2312.9	4289.6	449.3	58′
44°	2314.9	4292.7	450.0	**44°**
2′	2316.8	4295.8	450.7	2′
4′	2318.8	4298.9	451.5	4′
6′	2320.7	4302.0	452.2	6′
8′	2322.7	4305.1	452.9	8′
10′	2324.6	4308.1	453.6	10′
12′	2326.6	4311.2	454.3	12′
14′	2328.5	4314.3	455.1	14′
16′	2330.5	4317.4	455.8	16′
18′	2332.4	4320.5	456.5	18′
20′	2334.3	4323.5	457.3	20′
22′	2336.3	4326.6	458.0	22′
24′	2338.2	4329.7	458.8	24′
26′	2340.2	4332.8	459.5	26′
28′	2342.1	4335.9	460.3	28′

Add 251.0 for Spiral No. 5.
" 452.7 " " 9.
" 705.6 " " 14.

Add 2.7 for Spiral No. 5.
" 7.8 " " 9.
" 17.5 " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
44° 30′	2344.0	4338.9	461.0	**44°** 30′
32′	2346.0	4342.0	461.8	32′
34′	2347.9	4345.1	462.5	34′
36′	2349.8	4348.2	463.3	36′
38′	2351.8	4351.3	464.0	38′
40′	2353.7	4354.4	464.7	40′
42′	2355.7	4357.5	465.5	42′
44′	2357.6	4360.6	466.2	44′
46′	2359.6	4363.7	467.0	46′
48′	2361.5	4366.7	467.7	48′
50′	2363.5	4369.8	468.4	50′
52′	2365.5	4372.9	469.2	52′
54′	2367.4	4376.0	469.9	54′
56′	2369.4	4379.0	470.7	56′
58′	2371.3	4382.1	471.4	58′
45°	2373.3	4385.2	472.1	**45°**
2′	2375.3	4388.3	472.8	2′
4′	2377.2	4391.4	473.6	4′
6′	2379.2	4394.5	474.3	6′
8′	2381.2	4397.6	475.1	8′
10′	2383.1	4400.6	475.8	10′
12′	2385.1	4403.7	476.6	12′
14′	2387.0	4406.8	477.3	14′
16′	2389.0	4409.9	478.1	16′
18′	2390.9	4413.0	478.8	18′
20′	2392.9	4416.0	479.6	20′
22′	2394.9	4419.0	480.4	22′
24′	2396.8	4422.1	481.1	24′
26′	2398.8	4425.2	481.9	26′
28′	2400.7	4428.3	482.7	28′
30′	2402.7	4431.3	483.4	30′
32′	2404.7	4434.4	484.2	32′
34′	2406.6	4437.5	485.0	34′
36′	2408.6	4440.5	485.7	36′
38′	2410.5	4443.6	486.5	38′
40′	2412.5	4446.7	487.2	40′
42′	2414.5	4449.8	488.0	42′
44′	2416.4	4452.8	488.8	44′
46′	2418.4	4455.9	489.5	46′
48′	2420.3	4459.0	490.3	48′
50′	2422.3	4462.1	491.0	50′
52′	2424.3	4465.1	491.8	52′
54′	2426.2	4468.2	492.5	54′
56′	2428.2	4471.3	493.3	56′
58′	2430.1	4474.4	494.1	58′

Add 251.0 for Spiral No. 5:
" 452.8 " " " 9:
" 705.8 " " " 14:

Add 2.7 for Spiral No. 5:
" 7.8 " " " 9:
" 17.6 " " " 14:

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
46°	2432.1	4477.5	494.8	**46°**
2′	2434.1	4480.6	495.6	2′
4′	2436.0	4483.6	496.3	4′
6′	2438.0	4486.7	497.1	6′
8′	2439.9	4489.8	497.9	8′
10′	2441.9	4492.8	498.7	10′
12′	2443.9	4495.9	499.5	12′
14′	2445.8	4498.9	500.3	14′
16′	2447.8	4502.0	501.0	16′
18′	2449.7	4505.1	501.8	18′
20′	2451.7	4508.1	502.6	20′
22′	2453.7	4511.2	503.4	22′
24′	2455.7	4514.3	504.2	24′
26′	2457.6	4517.3	504.9	26′
28′	2459.6	4520.4	505.7	28′
30′	2461.6	4523.4	506.5	30′
32′	2463.6	4526.5	507.3	32′
34′	2465.5	4529.6	508.0	34′
36′	2467.5	4532.6	508.8	36′
38′	2469.5	4535.7	509.6	38′
40′	2471.5	4538.8	510.4	40′
42′	2473.5	4541.8	511.2	42′
44′	2475.4	4544.9	512.0	44′
46′	2477.4	4548.0	512.7	46′
48′	2479.4	4551.0	513.5	48′
50′	2481.4	4554.1	514.3	50′
52′	2483.4	4557.2	515.1	52′
54′	2485.4	4560.2	515.9	54′
56′	2487.3	4563.3	516.6	56′
58′	2489.3	4566.4	517.4	58′
47°	2491.3	4569.4	518.2	**47°**
2′	2493.3	4572.4	519.0	2′
4′	2495.3	4575.5	519.8	4′
6′	2497.3	4578.5	520.6	6′
8′	2499.2	4581.6	521.4	8′
10′	2501.2	4584.6	522.2	10′
12′	2503.2	4587.7	523.0	12′
14′	2505.2	4590.7	523.8	14′
16′	2507.2	4593.8	524.6	16′
18′	2509.1	4596.8	525.4	18′
20′	2511.1	4599.9	526.2	20′
22′	2513.1	4602.9	527.0	22′
24′	2515.1	4606.0	527.8	24′
26′	2517.1	4609.0	528.6	26′
28′	2519.1	4612.1	529.4	28′

Add 251.1 for Spiral No. 5:
" 452.9 " " 9:
" 706.1 " " 14:

Add 2.8 for Spiral No. 5:
" 7.8 " " 9:
" 17.6 " " 14:

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
47° 30′	2521.0	4615.1	530.2	**47°** 30′
32′	2523.0	4618.2	531.0	32′
34′	2525.0	4621.2	531.8	34′
36′	2527.0	4624.3	532.6	36′
38′	2529.0	4627.3	533.4	38′
40′	2531.0	4630.4	534.2	40′
42′	2533.0	4633.4	535.0	42′
44′	2535.0	4636.5	535.8	44′
46′	2537.0	4639.5	536.6	46′
48′	2539.0	4642.6	537.4	48′
50′	2541.0	4645.6	538.2	50′
52′	2543.0	4648.7	539.0	52′
54′	2545.0	4651.7	539.8	54′
56′	2547.0	4654.8	540.6	56′
58′	2549.0	4657.8	541.4	58′
48°	2551.0	4660.9	542.3	**48°**
2′	2553.0	4663.9	543.1	2′
4′	2555.0	4667.0	544.0	4′
6′	2557.0	4670.0	544.8	6′
8′	2559.0	4673.1	545.6	8′
10′	2561.0	4676.1	546.4	10′
12′	2563.0	4679.1	547.2	12′
14′	2565.0	4682.2	548.0	14′
16′	2567.0	4685.2	548.9	16′
18′	2569.0	4688.2	549.7	18′
20′	2571.0	4691.3	550.5	20′
22′	2573.0	4694.3	551.3	22′
24′	2575.0	4697.3	552.2	24′
26′	2577.0	4700.4	553.0	26′
28′	2579.0	4703.4	553.8	28′
30′	2581.0	4706.4	554.6	30′
32′	2583.0	4709.5	555.4	32′
34′	2585.0	4712.5	556.2	34′
36′	2587.0	4715.5	557.0	36′
38′	2589.0	4718.6	557.9	38′
40′	2591.0	4721.6	558.7	40′
42′	2593.0	4724.6	559.5	42′
44′	2595.0	4727.6	560.3	44′
46′	2597.1	4730.7	561.2	46′
48′	2599.1	4733.7	562.0	48′
50′	2601.1	4736.8	562.8	50′
52′	2603.1	4739.8	563.6	52′
54′	2605.1	4742.8	564.4	54′
56′	2607.1	4745.9	565.3	56′
58′	2609.1	4748.9	566.1	58′

Add 706.4 for Spiral No. 14.

Add 251.1 for Spiral No. 5.
" 453.1 " " 9.

Add 706.5 for Spiral No. 14.

Add 2.8 for Spiral No. 5.
" 7.9 " " 9.
" 17.8 " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
49°	2611.2	4752.0	566.9	**49°**
2′	2613.2	4755.0	567.7	2′
4′	2615.2	4758.0	568.6	4′
6′	2617.2	4761.0	569.4	6′
8′	2619.2	4764.1	570.3	8′
10′	2621.2	4767.1	571.1	10′
12′	2623.3	4770.1	572.0	12′
14′	2625.3	4773.1	572.8	14′
16′	2627.3	4776.2	573.6	16′
18′	2629.3	4779.2	574.5	18′
20′	2631.3	4782.3	575.3	20′
22′	2633.4	4785.3	576.2	22′
24′	2635.4	4788.3	577.0	24′
26′	2637.4	4791.4	577.9	26′
28′	2639.4	4794.4	558.7	28′
30′	2641.4	4797.4	579.5	30′
32′	2643.5	4800.5	580.4	32′
34′	2645.5	4803.5	581.2	34′
36′	2647.5	4806.5	582.1	36′
38′	2649.5	4809.6	582.9	38′
40′	2651.5	4812.6	583.8	40′
42′	2653.6	4815.6	584.6	42′
44′	2655.6	4818.6	585.5	44′
46′	2657.6	4821.7	586.3	46′
48′	2659.6	4824.7	587.2	48′
50′	2661.6	4827.7	588.1	50′
52′	2663.7	4830.7	588.9	52′
54′	2665.7	4833.8	589.7	54′
56′	2667.7	4836.8	590.6	56′
58′	2669.7	4839.8	591.4	58′
50°	2671.7	4842.9	592.3	**50°**
2′	2673.7	4845.9	593.2	2′
4′	2675.8	4848.9	594.0	4′
6′	2677.8	4852.0	594.9	6′
8′	2679.8	4855.0	595.8	8′
10′	2681.9	4858.0	596.7	10′
12′	2683.9	4861.0	597.6	12′
14′	2686.0	4864.0	598.4	14′
16′	2688.0	4867.1	599.3	16′
18′	2610.1	4870.1	600.1	18′
20′	2692.1	4873.1	601.0	20′
22′	2694.1	4876.1	601.9	22′
24′	2696.2	4879.1	602.7	24′
26′	2698.2	4882.2	603.6	26′
28′	2700.3	4885.2	604.4	28′

Add 706.6 for Spiral No. 14.

Add 251.2 for Spiral No. 5.
" 453.2 " " 9.

Add 706.7 for Spiral No. 14.

Add 2.8 for Spiral No. 5.
" 7.9 " " 9.
" 17.9 " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
50° 30′	2702.3		4888.2	605.3		**50°** 30′
32′	2704.3		4891.2	606.2		32′
34′	2706.4		4894.2	607.0		34′
36′	2708.4		4897.2	607.9		36′
38′	2710.5		4900.2	608.8		38′
40′	2712.5		4903.2	609.7		40′
42′	2714.5	Add 706.9 for Spiral No. 14.	4906.2	610.6		42′
44′	2716.6		4909.2	611.5		44′
46′	2718.6		4912.2	612.3		46′
48′	2720.7		4915.2	613.2		48′
50′	2722.7		4918.2	614.1		50′
52′	2724.8		4921.3	615.0		52′
54′	2726.8		4924.3	615.8		54′
56′	2728.8		4927.3	616.7		56′
58′	2730.9		4930.3	617.6		58′
51°	2732.9		4933.3	618.5		**51°**
2′	2734.9		4936.3	619.4		2′
4′	2737.0		4939.3	620.3	Add 2.8 for Spiral No. 5. " 8.0 " " 9. " 18.1 " " 14.	4′
6′	2739.0		4942.3	621.2		6′
8′	2741.1	Add 251.2 for Spiral No. 5. " 453.3 " " 9. " 707.0 " " 14.	4945.3	622.0		8′
10′	2743.1		4948.3	622.9		10′
12′	2745.1		4951.3	623.8		12′
14′	2747.2		4954.3	624.7		14′
16′	2749.2		4957.3	625.6		16′
18′	2751.3		4960.3	626.4		18′
20′	2753.3		4963.3	627.3		20′
22′	2755.3		4966.3	628.2		22′
24′	2757.4		4969.3	629.1		24′
26′	2759.4		4972.3	630.0		26′
28′	2761.5		4975.3	630.8		28′
30′	2763.6		4978.3	631.7		30′
32′	2765.6	Add 707.1 for Spiral No. 14.	4981.3	632.6		32′
34′	2767.7		4984.3	633.5		34′
36′	2769.8		4987.3	634.4		36′
38′	2771.8		4990.3	635.3		38′
40′	2773.9		4993.3	636.2		40′
42′	2775.9		4996.3	637.1		42′
44′	2778.0		4999.3	638.0		44′
46′	2780.1		5002.3	638.9		46′
48′	2782.2		5005.3	639.8		48′
50′	2784.2		5008.3	640.7		50′
52′	2786.3		5011.3	641.6		52′
54′	2788.4		5014.3	642.5		54′
56′	2790.4		5017.3	643.4		56′
58′	2792.5		5020.3	644.3		58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
52°	2794.5	5023.3	645.2	**52°**
2′	2796.6	5026.3	646.1	2′
4′	2798.6	5029.3	647.0	4′
6′	2800.7	5032.3	647.9	6′
8′	2802.7	5035.3	648.8	8′
10′	2804.8	5038.3	649.7	10′
12′	2806.8	5041.3	650.6	12′
14′	2808.9	5044.3	651.5	14′
16′	2811.0	5047.3	652.4	16′
18′	2813.1	5050.3	653.3	18′
20′	2815.2	5053.3	654.3	20′
22′	2817.3	5056.3	655.2	22′
24′	2819.3	5059.3	656.1	24′
26′	2821.4	5062.3	657.0	26′
28′	2823.5	5065.3	658.0	28′
30′	2825.5	5068.3	658.9	30′
32′	2827.6	5071.3	659.8	32′
34′	2829.7	5074.3	660.7	34′
36′	2831.7	5077.3	661.6	36′
38′	2833.8	5080.3	662.5	38
40′	2835.9	5083.3	663.5	40′
42′	2837.9	5086.3	664.4	42′
44′	2840.0	5089.3	665.3	44′
46′	2842.1	5092.3	666.3	46′
48′	2844.2	5095.3	667.2	48′
50′	2846.3	5098.3	668.1	50′
52′	2848.4	5101.3	669.0	52′
54′	2850.4	5104.3	670.0	54′
56′	2852.5	5107.3	670.9	56′
58′	2854.6	5110.2	671.8	58′
53°	2856.7	5113.2	672.7	**53°**
2′	2858.8	5116.2	673.6	2′
4′	2860.8	5119.2	674.6	4′
6′	2862.9	5122.2	675.5	6′
8′	2865.0	5125.1	676.4	8′
10′	2867.1	5128.1	677.3	10′
12′	2869.2	5131.1	678.2	12′
14′	2871.3	5134.1	679.1	14′
16′	2873.4	5137.0	680.1	16′
18′	2875.5	5140.0	681.0	18′
20′	2877.5	5142.9	682.0	20′
22′	2879.6	5145.9	682.9	22′
24′	2881.7	5148.9	683.8	24′
26′	2883.8	5151.8	684.8	26′
28′	2885.8	5154.8	685.7	28′

Add 707.1 for Spiral No. 14.

Add 251.2 for Spiral No. 5.
" 453.4 " " 9.
Add 707.2 for Spiral No. 14.

Add 2.8 for Spiral No. 5.
" 8.0 " " 9.
" 18.2 " " 14.

Add 251.3 for Spiral No. 5.
" 453.5 " " 9.
" 707.3 for " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
53° 30′	2887.9	5157.8	686.7	**53°** 30′
32′	2890.0	5160.8	687.6	32′
34′	2892.1	5163.7	688.6	34′
36′	2894.2	5166.7	689.5	36′
38′	2896.3	5169.7	690.5	38′
40′	2898.4	5172.6	691.4	40′
42′	2900.5	5175.6	692.4	42′
44′	2902.6	5178.6	693.3	44′
46′	2904.7	5181.5	694.3	46′
48′	2906.8	5184.5	695.2	48′
50′	2908.9	5187.4	696.1	50′
52′	2911.0	5190.4	697.1	52′
54′	2913.1	5193.4	698.0	54′
56′	2915.2	5196.3	699.0	56′
58′	2917.3	5199.3	700.0	58′
54°	2919.4	5202.3	700.9	**54°**
2′	2921.5	5205.3	701.9	2′
4′	2923.6	5208.2	702.8	4′
6′	2925.7	5211.2	703.8	6′
8′	2927.8	5214.2	704.7	8′
10′	2929.9	5217.1	705.7	10′
12′	2932.0	5220.1	706.6	12′
14′	2934.1	5223.1	707.6	14′
16′	2936.2	5226.0	708.5	16′
18′	2938.3	5229.0	709.5	18′
20′	2940.4	5232.0	710.5	20′
22′	2942.5	5235.0	711.4	22′
24	2944.6	5237.9	712.4	24′
26′	2946.7	5240.9	713.4	26′
28′	2948.8	5243.9	714.3	28′
30′	2950.9	5246.8	715.3	30′
32′	2953.0	5249.8	716.3	32′
34′	2955.2	5252.8	717.2	34′
36′	2957.3	5255.7	718.2	36′
38′	2959.4	5258.7	719.2	38′
40′	2961.5	5261.6	720.1	40′
42′	2963.6	5264.6	721.1	42′
44′	2965.8	5267.6	722.1	44′
46′	2967.9	5270.5	723.1	46′
48′	2970.0	5273.5	724.0	48′
50′	2972.1	5276.5	725.0	50′
52′	2974.2	5279.5	726.0	52′
54′	2976.4	5282.4	727.0	54′
56′	2978.5	5285.4	728.0	56′
58′	2980.6	5288.3	728.9	58′

Add 251.3 for Spiral No. 5.
" 453.5 " " " 9.
" 707.4 " " " 14.

Add 2.9 for Spiral No. 5.
" 8.1 " " " 9.
" 18.3 " " " 14.

Add 251.3 for Spiral No. 5.
" 453.6 " " " 9.
" 707.5 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
55°	2982.7		5291.3	729.9		**55°**
2′	2984.8		5294.2	730.9		2′
4′	2987.0		5297.2	731.9		4′
6′	2989.1	Add 707.6 for Spiral No. 14.	5300.1	732.9		6′
8′	2991.2		5303.1	733.8		8′
10′	2993.3		5306.0	734.8		10′
12′	2995.4		5309.0	735.8		12′
14′	2997.6		5311.9	736.8		14′
16′	2999.7		5314.9	737.7		16′
18′	3001.8		5317.8	738.7		18′
20′	3003.9	Add 251.3 for Spiral No. 5. " 453.6 " " 9.	5320.8	739.7		20′
22′	3006.0		5323.7	740.7		22′
24′	3008.2		5326.7	741.7		24′
26′	3010.3		5329.6	472.6		26′
28′	3012.4		5332.6	743.6		28′
30′	3014.5		5335.5	744.6		30′
32′	3016.6		5338.5	745.6		32′
34′	3018.8	Add 707.7 for Spiral No. 14.	5341.4	746.6	Add 2.9 for Spiral No. 5. " 8.1 " " " 9. " 18.4 " " " 14.	34′
36′	3020.9		5344.4	747.6		36′
38′	3023.0		5347.3	748.6		38′
40′	3025.1		5350.2	749.6		40′
42′	3027.3		5353.2	750.6		42′
44′	3029.4		5356.1	751.6		44′
46′	3031.5		5359.1	752.6		46′
48′	3033.7		5362.0	753.6		48′
50′	3035.8		5365.0	754.6		50′
52′	3037.9		5367.9	755.6		52′
54′	3040.0		5370.9	756.6		54′
56′	3042.2		5373.8	757.6		56′
58′	3044.3		5376.8	758.6		58′
56°	3046.5		5379.7	759.6		**56°**
2′	3048.6	Add 251.4 for Spiral No. 5. " 453.7 " " " 9. " 707.8 " " No. 14.	5382.7	760.6		2′
4′	3050.8		5385.6	761.6		4′
6′	3052.9		5388.6	762.6		6′
8′	3055.1		5391.5	763.6		8′
10′	3057.2		5394.4	764.6		10′
12′	3059.2		5397.4	765.6		12′
14′	3061.4		5400.3	766.7		14′
16′	3063.6		5403.2	767.7		16′
18′	3065.8		5406.2	768.7		18′
20′	3067.9		5409.1	769.7		20′
22′	3070.0		5412.0	770.7		22′
24′	3072.2		5415.0	771.7		24′
26′	3074.4		5417.9	772.8		26′
28′	3076.5		5420.8	773.8		28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
56° 30′	3078.6		5423.7	774.8		**56°** 30′
32′	3080.8		5426.7	775.8		32′
34′	3082.9		5429.6	776.8		34′
36′	3085.1	Add 251.4 for Spiral No. 5. " 453.7 " " 9. " 707.9 " " 14.	5432.5	777.9		36′
38′	3087.3		5435.5	778.9		38′
40′	3089.4		5438.4	779.9		40′
42′	3091.6		5441.3	780.9		42′
44′	3093.8		5444.3	782.0		44′
46′	3095.9		5447.2	783.0		46′
48′	3098.0		5450.1	784.0		48′
50′	3100.1		5453.1	785.0		50′
52′	3102.3		5456.0	786.0		52′
54′	3104.4		5458.9	787.0		54′
56′	3106.6		5461.9	788.1		56′
58′	3108.7		5464.8	789.1		58′
57°	3110.9		5467.8	790.1		**57°**
2′	3113.0		5470.7	791.2		2′
4′	3115.2		5473.6	792.2		4′
6′	3117.4	Add 708.0 for Spiral No. 14.	5476.6	793.2	Add 2.9 for Spiral No. 5. " 8.2 " " 9. " 18.6 " " 14.	6′
8′	3119.6		5479.5	794.3		8′
10′	3121.7		5482.4	795.3		10′
12′	3123.9		5485.3	796.3		12′
14′	3126.0		5488.3	797.4		14′
16′	3128.2		5491.2	798.4		16′
18′	3130.4		5494.1	799.5		18′
20′	3132.5	Add 251.4 for Spiral No. 5. " 453.8 " " 9.	5497.0	800.5		20′
22′	3134.7		5499.9	801.5		22′
24′	3136.8		5502.8	802.6		24′
26′	3139.0		5505.8	803.6		26′
28′	3141.2		5508.7	804.7		28′
30′	3143.3		5511.6	805.7		30′
32′	3145.5	Add 708.1 for Spiral No. 14.	5514.6	806.7		32′
34′	3147.6		5517.5	807.8		34′
36′	3149.8		5520.4	808.8		36′
38′	3152.0		5523.4	809.9		38′
40′	3154.2		5526.3	810.9		40′
42′	3156.4		5529.2	811.9		42′
44′	3158.5		5532.1	813.0		44′
46′	3160.7		5535.0	814.0		46′
48′	3162.9		5538.0	815.1		48′
50′	3165.1		5540.9	816.1		50′
52′	3167.2		5543.8	817.2		52′
54′	3169.4		5546.7	818.2		54′
56′	3171.6		5549.7	819.3		56′
58′	3173.8		5552.6	820.3		58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
58°	3176.0	5555.5	821.4	**58°**
2′	3178.2	5558.4	822.4	2′
4′	3180.4	5561.3	823.5	4′
6′	3182.6 Add 708.2 for Spiral No. 14.	5564.2	824.6	6′
8′	3184.8	5567.1	825.6 Add 8.2 for Spiral No. 9. " 18.7 " " " 14.	8′
10′	3186.9	5570.0	826.7	10′
12′	3189.1	5573.0	827.7	12′
14′	3191.3	5575.9	828.8	14′
16′	3193.5	5578.8	829.9	16′
18′	3195.7	5581.7	831.0	18′
20′	3197.8 Add 251.4 for Spiral No. 5. " 453.9 " " " 9.	5584.6	832.0	20′
22′	3200.0	5587.5	833.1	22′
24′	3202.2	5590.4	834.1	24′
26′	3204.4	5593.3	835.2	26′
28′	3206.6	5596.2	836.2	28′
30′	3208.7	5599.1	837.3	30′
32′	3210.9 Add 708.3 for Spiral No. 14.	5602.0	838.3	32′
34′	3213.1	5604.9	839.4	34′
36′	3215.3	5607.8	840.5	36′
38′	3217.5	5610.7	841.6	38′
40′	3219.7	5613.6	842.7	40′
42′	3221.9	5616.6	843.8	42′
44′	3224.1	5619.5	844.9	44′
46′	3226.3	5622.4	845.9	46′
48′	3228.5	5625.3	847.0	48′
50′	3230.7	5628.2	848.1 Add 2.9 for Spiral No. 5. " 8.3 " " " 9. " 18.8 " " " 14.	50′
52′	3232.9	5631.1	849.2	52′
54′	3235.1	5634.0	850.3	54′
56′	3237.3	5636.9	851.4	56′
58′	3239.5	5639.8	852.4	58′
59°	3241.7	5642.7	853.5	**59°**
2′	3243.9 Add 454.0 for Spiral No. 9. " 708.4 " " " 14.	5645.6	854.6	2′
4′	3246.1	5648.5	855.6	4′
6′	3248.3	5651.4	856.7	6′
8′	3250.5	5654.3	857.8	8′
10′	3252.7	5657.2	858.9	10′
12′	3254.9	5660.1	860.0	12′
14′	3257.1	5663.0	861.1	14′
16′	3259.3	5665.9	862.2	16′
18′	3261.5	5668.8	863.3	18′
20′	3263.7	5671.7	864.4	20′
22′	3266.0	5674.6	865.5	22′
24′	3268.2	5677.5	866.6	24′
26′	3270.4	5680.4	867.7	26′
28′	3272.6	5683.3	868.8	28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
59° 30′	3274.8	Add 708.5 for Spiral No. 14.	5686.2	869.9	Add 18.8 for Spiral No. 14.	**59°** 30′
32′	3277.0		5689.1	871.0		32′
34′	3279.2		5691.9	872.1		34′
36′	3281.4		5694.8	873.2		36′
38′	3283.6		5697.7	874.3		38′
40′	3285.8		5700.6	875.4		40′
42′	3288.0		5703.5	876.5		42′
44′	3290.2		5706.4	877.6		44′
46′	3292.4		5709.3	878.7		46′
48′	3294.7		5712.2	879.8		48′
50′	3296.9		5715.1	880.9		50′
52′	3299.1		5717.9	882.0		52′
54′	3301.4		5720.8	883.1		54′
56′	3303.6		5723.7	884.2		56′
58′	3305.8		5726.6	885.3		58′
60°	3308.0	Add 251.5 for Spiral No. 5. " 454.0 " " 9. " 708.6 " " 14.	5729.6	886.4	Add 2.9 for Spiral No. 5. " 8.3 " " 9.	**60°**
2′	3310.3		5732.5	887.5		2′
4′	3312.5		5735.4	888.6		4′
6′	3314.7		5738.2	889.7		6′
8′	3316.9		5741.1	890.9		8′
10′	3319.1		5744.0	892.0		10′
12′	3321.3		5746.9	893.1		12′
14′	3323.5		5749.8	894.2		14′
16′	3325.7		5752.7	895.4		16′
18′	3328.0		5755.5	896.5		18′
20′	3330.2		5758.4	897.6	Add 18.9 for Spiral No. 14.	20′
22′	3332.4		5761.3	898.7		22′
24′	3334.7		5764.2	899.8		24′
26′	3336.9		5767.1	901.0		26′
28′	3339.1		5769.9	902.1		28′
30′	3341.4	Add 708.7 for Spiral No. 14.	5772.8	903.2		30′
32′	3343.6		5775.7	904.3		32′
34′	3345.9		5778.6	905.4		34′
36′	3348.1		5781.5	906.6		36′
38′	3350.3		5784.3	907.7		38′
40′	3352.6		5787.2	908.8		40′
42′	3354.8		5790.1	910.0		42′
44′	3357.1		5793.0	911.1		44′
46′	3359.3		5795.9	912.2		46′
48′	3361.5		5798.7	913.3		48′
50′	3363.8		5801.6	914.5		50′
52′	3366.0		5804.5	915.6		52′
54′	3368.3		5807.4	916.7		54′
56′	3370.5		5810.2	917.9		56′
58′	3372.8		5813.1	919.1		58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
61°	3375.0	Add 708.8 for Spiral No. 14.	5816.0	920.2		**61°**
2′	3377.3		5818.9	921.3		2′
4′	3379.5		5821.7	922.5		4′
6′	3381.8		5824.6	923.6		6′
8′	3384.0		5827.5	924.8		8′
10′	3386.2		5830.3	925.9		10′
12′	3388.5		5833.2	927.0		12′
14′	3390.7		5836.0	928.2		14′
16′	3393.0		5838.9	929.4		16′
18′	3395.2		5841.8	930.5		18′
20′	3397.5		5844.7	931.6	Add 2.9 for Spiral No. 5. " 8.3 " " " 9. " 18.9 " " " 14.	20′
22′	3399.8		5847.6	932.8		22′
24′	3402.0		5850.4	933.9		24′
26′	3404.3		5853.3	935.1		26′
28′	3406.5		5856.2	936.3		28′
30′	3408.8		5859.0	937.4		30′
32′	3411.1		5861.9	938.6		32′
34′	3413.3	Add 251.5 for Spiral No. 5. " 454.1 " " " 9. " 708.9 " " " 14.	5864.8	939.7		34′
36′	3415.6		5867.6	940.9		36′
38′	3417.8		5870.5	942.1		38′
40′	3420.1		5873.3	943.2		40′
42′	3422.4		5876.2	944.4		42′
44′	3424.6		5879.1	945.5		44′
46′	3426.9		5882.0	946.7		46′
48′	3429.1		5884.8	947.9		48′
50′	3431.4		5887.7	949.0		50′
52′	3433.7		5890.6	950.2		52′
54′	3435.9		5893.4	951.3		54′
56′	3438.2		5896.3	952.5		56′
58′	3440.5		5899.1	953.6		58′
62°	3442.7		5902.0	954.8		**62°**
2′	3445.0	Add 709.0 for Spiral No. 14.	5904.8	956.0	Add 3.0 for Spiral No. 5. " 8.4 " " " 9. " 19.0 " " " 14.	2′
4′	3447.2		5907.7	957.2		4′
6′	3449.5		5910.5	958.3		6′
8′	3451.8		5913.4	959.5		8′
10′	3454.1		5916.2	960.7		10′
12′	3456.4		5919.1	961.9		12′
14′	3458.6		5921.9	963.1		14′
16′	3460.9		5924.8	964.3		16′
18′	3463.2		5927.6	965.4		18′
20′	3465.5		5930.5	966.6		20′
22′	3467.8		5933.3	967.8		22′
24′	3470.0		5936.1	969.0		24′
26′	3472.3		5939.0	970.1		26′
28′	3474.6		5941.8	971.3		28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
62° 30′	3476.9	5944.7	972.5	**62°** 30′
32′	3479.2	5947.5	973.7	32′
34′	3481.5	5950.4	974.9	34′
36′	3483.8 Add 251.5 for Spiral No. 5. " 454.2 " " 9. " 709.1 " " 14.	5953.2	976.0	36′
38′	3486.0	5956.1	977.2	38′
40′	3488.3	5958.9	978.4	40′
42′	3490.6	5961.8	979.6	42′
44′	3492.9	5964.7	980.8	44′
46′	3495.2	5967.5	982.0	46′
48′	3497.5	5970.4	983.1 Add 19.1 for Spiral No. 14.	48′
50′	3499.7	5973.2	984.3	50′
52′	3502.0	5976.1	985.5	52′
54′	3504.2	5978.9	986.7	54′
56′	3506.5	5981.8	987.9	56′
58′	3508.8	5984.6	989.1	58′
63°	3511.1	5987.4	990.3	**63°**
2′	3513.4	5990.3	991.5	2′
4′	3515.7	5993.1	992.7 Add 3.0 for Spiral No. 5. " 8.4 " " 9.	4′
6′	3518.0	5996.0	993.9	6′
8′	3520.3	5998.8	995.1	8′
10′	3522.6	6001.6	996.3	10′
12′	3524.9	6004.4	997.5	12′
14′	3527.2	6007.2	998.7	14′
16′	3529.5	6010.1	999.9	16′
18′	3531.8 Add 251.6 for Spiral No. 5. " 454.3 " " 9. " 709.2 " " 14.	6012.9	1001.1	18′
20′	3534.1	6015.8	1002.3 Add 19.2 for Spiral No. 14.	20′
22′	3536.4	6018.6	1003.5	22′
24′	3538.7	6021.4	1004.7	24′
26′	3541.0	6024.2	1006.0	26′
28′	3543.3	6027.0	1007.2	28′
30′	3545.6	6029.9	1008.4	30′
32′	3547.9	6032.7	1009.6	32′
34′	3550.2	6035.6	1010.8	34′
36′	3552.5	6038.4	1012.1	36′
38′	3554.8	6041.3	1013.3	38′
40′	3557.1	6044.1	1014.5	40′
42′	3559.4	6047.0	1015.7	42′
44′	3561.7	6049.8	1016.9	44′
46′	3564.0	6052.6	1018.2	46′
48′	3566.3	6055.5	1019.4	48′
50′	3568.7	6058.3	1020.6	50′
52′	3571.0	6061.2	1021.8	52′
54′	3573.3	6064.0	1023.0	54′
56′	3575.6	6066.9	1024.3	56′
58′	3577.9	6069.7	1025.5	58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
64°	3580.2	6072.5	1026.7	**64°**
2′	3582.6	6075.3	1027.9	2′
4′	3584.9	6078.1	1029.2	4′
6′	3587.2	6081.0	1030.4	6′
8′	3589.5	6083.8	1031.7	8′
10′	3591.8	6086.6	1032.9	10′
12′	3594.2	6089.4	1034.1	12′
14′	3596.5	6092.2	1035.4	14′
16′	3598.8	6095.0	1036.6	16′
18′	3601.1	6097.8	1037.9	18′
20′	3603.4	6100.7	1039.1	20′
22′	3605.7	6103.5	1040.3	22′
24′	3608.1	6106.3	1041.6	24′
26′	3610.4	6109.2	1042.8	26′
28′	3612.8	6112.0	1044.1	28′
30′	3615.1	6114.8	1045.3	30′
32′	3617.5	6117.6	1046.5	32′
34′	3619.8	6120.4	1047.8	34′
36′	3622.1	6123.2	1049.0	36′
38′	3624.5	6126.0	1050.3	38′
40′	3626.8	6128.9	1051.5	40′
42′	3629.2	6131.7	1052.7	42′
44′	3631.5	6134.5	1054.0	44′
46′	3633.8	6137.3	1055.2	46′
48′	3636.2	6140.1	1056.5	48′
50′	3638.5	6143.0	1057.7	50′
52′	3640.9	6145.8	1059.0	52′
54′	3643.2	6148.6	1060.2	54′
56′	3645.5	6151.4	1061.5	56′
58′	3647.9	6154.2	1062.7	58′
65°	3650.2	6157.0	1063.9	**65°**
2′	3652.6	6159.8	1065.2	2′
4′	3654.9	6162.6	1066.4	4′
6′	3657.3	6165.4	1067.7	6′
8′	3659.6	6168.2	1068.9	8′
10′	3661.9	6171.0	1070.2	10′
12′	3664.3	6173.8	1071.4	12′
14′	3666.7	6176.6	1072.7	14′
16′	3669.0	6179.4	1073.9	16′
18′	3671.3	6182.2	1075.2	18′
20′	3673.6	6185.1	1076.5	20′
22′	3676.0	6187.9	1077.7	22′
24′	3678.3	6190.7	1079.0	24′
26′	3680.6	6193.5	1080.3	26′
28′	3683.0	6196.3	1081.6	28′

Add 709.3 for Spiral No. 14.
Add 454.4 for Spiral No. 9.
Add 251.6 for Spiral No. 5.
Add 709.4 for Spiral No. 14.
Add 454.5 for Spiral No. 9.
Add 709.5 for Spiral No. 14.

Add 19.3 for Spiral No. 14.
Add 3.0 for Spiral No. 5.
" 8.5 " " " 9.
Add 19.4 for Spiral No. 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.			Long Chord.	External Secant.			Whole Angle.
65° 30′	3685.4			6199.1	1082.9			**65°** 30′
32′	3687.7			6201.9	1084.2			32′
34′	3690.1	Add 251.6 for Spiral No. 5. " 454.5 " " 9.	" 709.6 " " 14.	6204.7	1085.5			34′
36′	3692.4			6207.5	1086.7			36′
38′	3694.8			6210.3	1088.0			38′
40′	3697.2			6213.2	1089.3			40′
42′	3699.5			6216.0	1090.6			42′
44′	3701.9			6218.8	1091.9			44′
46′	3704.2			6221.6	1093.1			46′
48′	3706.6			6224.4	1094.4			48′
50′	3709.0			6227.2	1095.7		Add 19.4 for Spiral No. 14.	50′
52′	3711.3			6230.0	1097.0			52′
54′	3713.7			6232.8	1098.3			54′
56′	3716.1			6235.6	1099.6			56′
58′	3718.5			6238.4	1100.9			58′
66°	3720.8			6241.2	1102.2			**66°**
2′	3723.2			6244.0	1103.5			2′
4′	3725.5			6246.8	1104.8			4′
6′	3727.9		Add 709.7 for Spiral No. 14.	6249.6	1106.0	Add 3.0 for Spiral No. 5. " 8.5 " " 9.		6′
8′	3730.3			6252.3	1107.3			8′
10′	3732.7			6255.1	1108.6			10′
12′	3735.1			6257.9	1109.9			12′
14′	3737.5			6260.7	1111.2			14′
16′	3739.8			6263.5	1112.5			16′
18′	3742.2			6266.3	1113.8			18′
20′	3744.6	Add 251.7 for Spiral No. 5. " 454.6 " " 9.		6269.1	1115.1			20′
22′	3747.0			6271.9	1116.4		Add 19.5 for Spiral No. 14.	22′
24′	3749.4			6274.7	1117.7			24′
26′	3751.7			6277.5	1119.1			26′
28′	3754.1			6280.2	1120.4			28′
30′	3756.5			6283.0	1121.7			30′
32′	3758.9			6285.8	1123.0			32′
34′	3761.3		Add 709.8 for Spiral No. 14.	6288.6	1124.3			34′
36′	3763.7			6291.4	1125.6			36′
38′	3766.0			6294.1	1126.9			38′
40′	3768.4			6296.9	1128.2			40′
42′	3770.8			6299.7	1129.5			42′
44′	3773.2			6302.5	1130.8			44′
46′	3775.6			6305.3	1132.2			46′
48′	3778.0			6308.1	1133.5			48′
50′	3780.4			6310.9	1134.8			50′
52′	3782.8			6313.7	1136.1			52′
54′	3785.2			6316.5	1137.4			54′
56′	3787.6			6319.2	1138.8			56′
58′	3790.0			6322.0	1140.1			58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
67°	3792.4		6324.8	1141.4		**67°**
2′	3794.8		6327.5	1142.7		2′
4′	3797.2		6330.3	1144.0		4′
6′	3799.6		6333.1	1145.4		6′
8′	3802.0		6335.8	1146.7		8′
10′	3804.4		6338.6	1148.0		10′
12′	3806.8		6341.4	1149.4		12′
14′	3809.2	Add 709.0 for Spiral No. 14.	6344.2	1150.7		14′
16′	3811.6		6346.9	1152.0		16′
18′	3814.0		6349.7	1153.4		18′
20′	3816.4		6352.5	1154.7		20′
22′	3818.8		6355.3	1156.0		22′
24′	3821.2		6358.1	1157.4		24′
26′	3823.6		6360.8	1158.7		26′
28′	3826.0		6363.6	1160.0		28′
30′	3828.4	Add 454.7 for Spiral No. 9.	6366.3	1161.4	Add 3.0 for Spiral No. 5. " 19.6 " " 14.	30′
32′	3830.9		6369.1	1162.7		32′
34′	3833.3		6371.8	1164.1		34′
36′	3835.7		6374.6	1165.4		36′
38′	3838.1		6377.3	1166.7		38′
40′	3840.5		6380.1	1168.1		40′
42′	3843.0		6382.8	1169.4		42′
44′	3845.4	Add 710.0 for Spiral No. 14.	6385.6	1170.8		44′
46′	3847.8	Add 251.7 for Spiral No. 5.	6388.4	1172.1		46′
48′	3850.2		6391.2	1173.4		48′
50′	3852.6		6394.0	1174.8		50′
52′	3855.1		6396.7	1176.1		52′
54′	3857.5		6399.5	1177.5		54′
56′	3859.9		6402.3	1178.8		56′
58′	3862.3		6405.1	1180.2		58′
68°	3864.7		6407.9	1181.6		**68°**
2′	3867.1		6410.7	1183.0		2′
4′	3869.6	Add 454.8 for Spiral No. 9.	6413.5	1184.3		4′
6′	3872.0		6416.2	1185.7		6′
8′	3874.4		6419.0	1187.0		8′
10′	3876.8		6421.7	1188.4		10′
12′	3879.3		6424.5	1189.7		12′
14′	3881.7		6427.2	1191.1		14′
16′	3884.2	Add 710.1 for Spiral No. 14.	6429.9	1192.4	Add 3.1 for Spiral No. 5. " 8.6 " " 9. " 10.7 " " 14.	16′
18′	3886.6		6432.6	1193.8		18′
20′	3889.0		6435.4	1195.2		20′
22′	3891.5		6438.1	1196.5		22′
24′	3893.9		6440.9	1197.9		24′
26′	3896.4		6443.7	1199.2		26′
28′	3898.8		6446.4	1200.6		28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
68° 30′	3901.2	6449.2	1202.0	**68°** 30′
32′	3903.7	6452.0	1203.3	32′
34′	3906.1	6454.7	1204.7	34′
36′	3908.5	6457.5	1206.1	36′
38′	3910.8	6460.2	1207.5	38′
40′	3913.4	6463.0	1208.9	40′
42′	3915.9	6465.7	1210.3	42′
44′	3918.3	6468.5	1211.6	44′
46′	3920.7	6471.3	1213.0	46′
48′	3923.2	6474.0	1214.4	48′
50′	3925.6	6476.8	1215.8	50′
52′	3928.0	6479.5	1217.2	52′
54′	3930.5	6482.3	1218.6	54′
56′	3932.9	6485.0	1220.0	56′
58′	3935.4	6487.8	1221.4	58′
69°	3937.9	6490.6	1222.8	**69°**
2′	3940.4	6493.3	1224.2	2′
4′	3942.8	6496.1	1225.6	4′
6′	3945.3	6498.8	1227.0	6′
8′	3947.8	6501.6	1228.4	8′
10′	3950.2	6504.3	1229.8	10′
12′	3952.7	6507.1	1231.2	12′
14′	3955.1	6509.8	1232.6	14′
16′	3957.6	6512.6	1234.0	16′
18′	3960.0	6515.3	1235.4	18′
20′	3962.5	6518.0	1236.8	20′
22′	3965.0	6520.8	1238.2	22′
24′	3967.4	6523.5	1239.6	24′
26′	3969.9	6526.3	1241.0	26′
28′	3972.3	6529.0	1242.4	28′
30′	3974.8	6531.7	1243.8	30′
32′	3977.3	6534.5	1245.2	32′
34′	3979.7	6537.2	1246.6	34′
36′	3982.2	6540.0	1248.0	36′
38′	3984.6	6542.7	1249.4	38′
40′	3987.1	6545.4	1250.8	40′
42′	3989.6	6548.2	1252.2	42′
44′	3992.0	6550.9	1253.6	44′
46′	3994.5	6553.7	1255.0	46′
48′	3997.0	6556.4	1256.4	48′
50′	3999.5	6559.1	1257.9	50′
52′	4002.0	6561.9	1259.3	52′
54′	4004.5	6564.6	1260.7	54′
56′	4007.0	6567.4	1262.2	56′
58′	4009.5	6570.1	1263.6	58′

Add 454.8 251.7 for Spiral No. 9.
Add 710.2 for Spiral No. 14.

Add 251.7 for Spiral No. 5.
Add 710.3 for Spiral No. 14.

Add 454.9 for Spiral No. 9.
Add 710.4 for Spiral No. 14.

Add 8.6 for Spiral No. 9.
" 19.7 " " 14.

Add 3.1 for Spiral No. 5.

Add 8.7 for Spiral No. 9.
" 19.8 " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
70°	4011.9	6572.8	1265.0	**70°**
2′	4014.4	6575.5	1266.4	2′
4′	4016.9	6578.3	1267.8	4′
6′	4019.4	6581.0	1269.3	6′
8′	4021.9 Add 710.5 for Spiral No. 14.	6583.7	1270.7	8′
10′	4024.4	6586.4	1272.1	10′
12′	4026.9	6589.1	1273.5	12′
14′	4029.4	6591.9	1275.0	14′
16′	4031.9	6594.6	1276.4	16′
18′	4034.4	6597.3	1277.9	18′
20′	4036.8	6600.0	1279.3	20′
22′	4039.3	6602.7	1280.7	22′
24′	4041.8	6605.5	1282.2	24′
26′	4044.3	6608.2	1283.6	26′
28′	4046.8	6610.9	1285.1	28′
30′	4049.3	6613.6	1286.5	30′
32′	4051.8	6616.3	1288.0	32′
34′	4054.3	6619.0	1289.4 Add 3.1 for Spiral No. 5. " 8.8 " " 9. " 19.9 " " 14.	34′
36′	4056.8 Add 251.8 for Spiral No. 5. " 455.1 " " 9. " 710.8 " " 14.	6621.8	1290.8	36′
38′	4059.3	6624.5	1292.3	38′
40′	4061.8	6627.2	1293.7	40′
42′	4064.4	6629.9	1295.2	42′
44′	4066.9	6632.6	1296.6	44′
46′	4069.4	6635.4	1298.1	46′
48′	4071.9	6638.1	1299.5	48′
50′	4074.4	6640.8	1301.0	50′
52′	4076.9	6643.5	1302.4	52′
54′	4079.4	6646.2	1303.9	54′
56′	4081.9	6649.0	1305.3	56′
58′	4084.4	6651.7	1306.8	58′
71°	4086.9	6654.4	1308.3	**71°**
2′	4089.5 Add 710.6 for Spiral No. 14.	6657.1	1309.7	2′
4′	4092.0	6659.9	1311.2	4′
6′	4094.5	6662.6	1312.6	6′
8′	4097.0	6665.3	1314.1	8′
10′	4099.5	6668.0	1315.6	10′
12′	4102.0	6670.7	1317.0	12′
14′	4104.6	6673.4	1318.5	14′
16′	4107.0	6676.1	1320.0	16′
18′	4109.5	6678.8	1321.4	18′
20′	4112.1	6681.5	1322.9	20′
22′	4114.6	6684.2	1324.4	22′
24′	4117.2	6686.9	1325.8	24′
26′	4119.7	6689.6	1327.3	26′
28′	4122.2	6692.3	1328.8	28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
71° 30′	4124.7	6695.0	1330.3	**71°** 30′
32′	4127.3	6697.7	1331.8	32′
34′	4129.8	6700.4	1333.2	34′
36′	4132.4	6703.1	1334.7	36′
38′	4134.9	6705.8	1336.2	38′
40′	4137.4	6708.5	1337.7	40′
42′	4140.0	6711.2	1339.2	42′
44′	4142.5	6713.9	1340.6	44′
46′	4145.0	6716.6	1342.1	46′
48′	4147.6	6719.3	1343.6	48′
50′	4150.1	6722.0	1345.1	50′
52′	4152.7	6724.7	1346.6	52′
54′	4155.2	6727.4	1348.1	54′
56′	4157.8	6730.1	1349.6	56′
58′	4160.3	6732.8	1351.1	58′
72°	4162.8	6735.5	1352.6	**72°**
2′	4165.4	6738.2	1354.1	2′
4′	4167.9	6740.9	1355.6	4′
6′	4170.5	6743.6	1357.1	6′
8′	4173.0	6746.3	1358.6	8′
10′	4175.6	6749.0	1360.1	10′
12′	4178.1	6751.7	1361.6	12′
14′	4180.7	6754.4	1363.1	14′
16′	4183.2	6757.1	1364.6	16′
18′	4185.8	6759.8	1366.1	18′
20′	4188.4	6762.5	1367.6	20′
22′	4191.0	6765.1	1369.1	22′
24′	4193.5	6767.8	1370.6	24′
26′	4196.1	6770.5	1372.2	26′
28′	4198.6	6773.2	1373.7	28′
30′	4201.2	6775.9	1375.2	30′
32′	4203.8	6778.6	1376.7	32′
34′	4206.3	6781.3	1378.2	34′
36′	4208.9	6784.0	1379.8	36′
38′	4211.4	6786.7	1381.3	38′
40′	4214.0	6789.3	1382.8	40′
42′	4216.6	6792.0	1384.3	42′
44′	4219.1	6794.7	1385.8	44′
46′	4221.7	6797.4	1387.4	46′
48′	4224.2	6800.1	1388.9	48′
50′	4226.8	6802.7	1390.4	50′
52′	4229.4	6805.4	1391.9	52′
54′	4231.9	6808.0	1393.4	54′
56′	4234.5	6810.7	1395.0	56′
58′	4237.1	6813.4	1396.5	58′

Add 251.8 for Spiral No. 5.
" 455.1 " " " 9.
" 710.9 " " " 14.

Add 3.1 for Spiral No. 5.
" 8.8 " " " 9.
" 20.0 " " " 14.

Add 711.0 for Spiral No. 14.

Add 251.9 for Spiral No. 5.
" 455.2 " " " 9.

Add 3.2 for Spiral No. 5.
" 8.9 " " " 9.
" 20.1 " " " 14.

Add 711.1 for Spiral No. 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
73°	4239.7	6816.1	1398.0	**73°**
2′	4242.3	6818.8	1399.5	2′
4′	4244.8	6821.5	1401.1	4′
6′	4247.4	6824.2	1402.6	6′
8′	4250.0	6826.8	1404.2	8′
10′	4252.6	6829.5	1405.7	10′
12′	4255.2	6832.2	1407.3	12′
14′	4257.7	6834.9	1408.8	14′
16′	4260.3	6837.5	1410.4	16′
18′	4262.9	6840.2	1411.9	18′
20′	4265.5	6842.8	1413.5	20′
22′	4268.1	6845.5	1415.0	22′
24′	4270.7	6848.2	1416.6	24′
26′	4273.3	6850.9	1418.1	26′
28′	4275.9	6853.5	1419.7	28′
30′	4278.5	6856.2	1421.2	30′
32′	4281.1	6858.9	1422.8	32′
34′	4283.7	6861.6	1424.3	34′
36′	4286.3	6864.3	1425.9	36′
38′	4288.9	6866.9	1427.4	38′
40′	4291.5	6869.6	1429.0	40′
42′	4294.1	6872.3	1430.6	42′
44′	4296.7	6874.9	1432.1	44′
46′	4299.3	6877.6	1433.7	46′
48′	4301.9	6880.2	1435.2	48′
50′	4304.5	6882.9	1436.8	50′
52′	4307.1	6885.5	1438.4	52′
54′	4309.7	6888.2	1439.9	54′
56′	4312.3	6890.9	1441.5	56′
58′	4314.9	6893.6	1443.0	58′
74°	4317.6	6896.3	1444.6	**74°**
2′	4320.2	6899.0	1446.2	2′
4′	4322.9	6901.6	1447.8	4′
6′	4325.5	6904.3	1449.3	6′
8′	4328.1	6906.9	1450.9	8′
10′	4330.7	6909.6	1452.5	10′
12′	4333.4	6912.2	1454.1	12′
14′	4336.0	6914.8	1455.7	14′
16′	4338.6	6917.5	1457.2	16′
18′	4341.2	6920.1	1458.8	18′
20′	4343.8	6922.8	1460.4	20′
22′	4346.5	6925.5	1462.0	22′
24′	4349.1	6928.2	1463.6	24′
26′	4351.7	6930.8	1465.2	26′
28′	4354.3	6933.5	1466.8	28′

Add 711.3 for Spiral No. 14.

Add 251.9 for Spiral No. 5.
" 455.3 " " " 9.

Add 711.5 for Spiral No. 14.

Add 3.1 for Spiral No. 5.
" 8.9 " " " 9.
" 20.3 " " " 14.

Add 3.2 for Spiral No. 5.
" 9.0 " " " 9.
" 20.4 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
74° 30′	4356.9	6936.1	1468.4	**74°** 30′
32′	4359.6	6938.8	1470.0	32′
34′	4362.2	6941.5	1471.6	34′
36′	4364.9	6944.1	1473.2	36′
38′	4367.5	6946.8	1474.8	38′
40′	4370.1	6949.4	1476.4	40′
42′	4372.8	6952.0	1478.0	42′
44′	4375.4	6954.7	1479.6	44′
46′	4378.1	6957.3	1481.2	46′
48′	4380.7	6960.0	1482.8	48′
50′	4383.3	6962.6	1484.4	50′
52′	4386.0	6965.2	1486.0	52′
54′	4388.6	6967.9	1487.6	54′
56′	4391.2	6970.5	1489.2	56′
58′	4393.9	6973.2	1490.8	58′
75°	4396.5	6975.9	1492.4	**75°**
2′	4399.2	6978.6	1494.0	2′
4′	4401.8	6981.2	1495.6	4′
6′	4404.5	6983.9	1497.3	6′
8′	4407.1	6986.5	1498.9	8′
10′	4409.8	6989.1	1500.5	10′
12′	4412.5	6991.8	1502.1	12′
14′	4415.1	6994.4	1503.7	14′
16′	4417.8	6997.0	1505.4	16′
18′	4420.5	6999.7	1507.0	18′
20′	4423.1	7002.3	1508.6	20′
22′	4425.8	7005.0	1510.2	22′
24′	4428.4	7007.6	1511.8	24′
26′	4431.1	7010.2	1513.5	26′
28′	4433.8	7012.8	1515.1	28′
30′	4436.4	7015.4	1516.7	30′
32′	4439.1	7018.0	1518.3	32′
34′	4441.7	7020.7	1520.0	34′
36′	4444.4	7023.3	1521.6	36′
38′	4447.1	7026.0	1523.3	38′
40′	4449.7	7028.6	1524.9	40′
42′	4452.4	7031.2	1526.5	42′
44′	4455.0	7033.9	1528.2	44′
46′	4457.7	7036.5	1529.8	46′
48′	4460.4	7039.2	1531.5	48′
50′	4463.1	7041.8	1533.1	50′
52′	4465.8	7044.4	1534.7	52′
54′	4468.4	7047.1	1536.4	54′
56′	4471.1	7049.7	1538.0	56′
58′	4473.8	7052.3	1539.7	58′

Add 251.9 for Spiral No. 5.
" 455.4 " " " 9.
" 711.6 " " " 14.

Add 3.2 for Spiral No. 5.
" 9.0 " " " 9.
" 20.4 " " " 14.

Add 711.7 for Spiral No. 14.

Add 252.0 for Spiral No. 5.
" 455.5 " " " 9.

Add 3.2 for Spiral No. 5.
" 9.1 " " " 9.
" 20.5 " " " 14.

Add 711.8 for Spiral No. 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
76°	4476.5	7055.0	1541.4	**76°**
2′	4479.2	7057.6	1543.0	2′
4′	4481.8	7060.2	1544.7	4′
6′	4484.5	7062.8	1546.3	6′
8′	4487.1	7065.4	1548.0	8′
10′	4489.9	7068.1	1549.7	10′
12′	4492.6	7070.7	1551.3	12′
14′	4495.3	7073.3	1553.0	14′
16′	4498.0	7075.9	1554.7	16′
18′	4500.7	7078.5	1556.3	18′
20′	4503.4	7081.2	1558.0	20′
22′	4506.1	7083.8	1559.7	22′
24′	4508.8	7086.4	1561.3	24′
26′	4511.4	7089.0	1563.0	26′
28′	4514.1	7091.6	1564.7	28′
30′	4516.9	7094.2	1566.4	30′
32′	4519.6	7096.8	1568.1	32′
34′	4522.3	7099.4	1569.8	34′
36′	4525.0	7102.0	1571.4	36′
38′	4527.7	7104.6	1573.1	38′
40′	4530.4	7107.3	1574.8	40′
42′	4533.2	7109.9	1576.5	42′
44′	4535.9	7112.5	1578.2	44′
46′	4538.6	7115.1	1579.8	46′
48′	4541.3	7117.7	1581.5	48′
50′	4544.0	7120.4	1583.2	50′
52′	4546.8	7123.0	1584.9	52′
54′	4549.5	7125.6	1586.6	54′
56′	4552.2	7128.2	1588.2	56′
58′	4554.9	7130.8	1589.9	58′
77°	4557.6	7133.5	1591.6	**77°**
2′	4560.3	7136.1	1593.3	2′
4′	4563.0	7138.7	1595.0	4′
6′	4565.7	7141.3	1596.7	6′
8′	4568.4	7143.9	1598.4	8′
10′	4571.2	7146.5	1600.1	10′
12′	4573.9	7149.1	1601.8	12′
14′	4576.6	7151.7	1603.5	14′
16′	4579.3	7154.3	1605.2	16′
18′	4582.0	7156.9	1606.9	18′
20′	4584.8	7159.5	1608.6	20′
22′	4587.5	7162.1	1610.3	22′
24′	4590.3	7164.7	1612.0	24′
26′	4593.0	7167.3	1613.7	26′
28′	4595.7	7169.9	1615.4	28′

Add 252.0 for Spiral No. 5.
" 455.6 " " " 4.

Add 711.9 for Spiral No. 14.

Add 712.0 for Spiral No. 14.

Add 3.2 for Spiral No. 5.
" 9.3 " " " 9.
" 20.8 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
77° 30′	4598.5	7172.5	1617.1	**77°** 30′
32′	4601.2	7175.1	1618.8	32′
34′	4604.0	7177.7	1620.5	34′
36′	4606.7	7180.3	1622.2	36′
38′	4609.5	7082.9	1624.0	38′
40′	4612.2	7185.5	1625.7	40′
42′	4615.0	7188.1	1627.5	42′
44′	4617.7	7190.7	1629.2	44′
46′	4620.5	7193.3	1630.9	46′
48′	4623.3	7195.9	1632.7	48′
50′	4626.0	7198.5	1634.4	50′
52′	4628.8	7201.1	1636.1	52′
54′	4631.5	7203.7	1637.9	54′
56′	4634.2	7206.3	1639.6	56′
58′	4637.0	7208.9	1641.3	38′
78°	4639.7	7211.5	1643.0	**78°**
2′	4642.5	7214.1	1644.8	2′
4′	4645.2	7216.7	1646.5	4′
6′	4648.0	7219.3	1648.3	6′
8′	4650.8	7221.9	1650.0	8′
10′	4653.5	7224.4	1651.7	10′
12′	4656.3	7227.0	1653.5	12′
14′	4659.0	7229.6	1655.2	14′
16′	4661.8	7232.2	1657.0	16′
18′	4664.6	7234.8	1658.7	18′
20′	4667.4	7237.3	1660.5	20′
22′	4670.2	7239.9	1662.3	22′
24′	4673.0	7242.5	1664.0	24′
26′	4675.7	7245.0	1665.8	26′
28′	4678.5	7247.6	1667.5	28′
30′	4681.3	7250.2	1669.3	30′
32′	4684.1	7252.8	1671.0	32′
34′	4686.9	7255.4	1672.8	34′
36′	4689.6	7258.0	1674.5	36′
38′	4692.4	7260.6	1676.3	38′
40′	4695.2	7263.2	1678.1	40′
42′	4698.0	7265.8	1679.9	42′
44′	4700.8	7268.3	1681.7	44′
46′	4703.6	7270.9	1683.4	46′
48′	4706.4	7273.5	1685.2	48′
50′	4709.2	7276.1	1687.0	50′
52′	4712.0	7278.7	1688.8	52′
54′	4714.8	7281.3	1690.6	54′
56′	4717.6	7283.9	1692.3	56′
58′	4720.4	7286.5	1694.1	58′

Add 252.0 for Spiral No. 5.
" 455.7 " " " 9.
" 712.2 " " " 14.

Add 3.3 for Spiral No. 5.
" 9.3 " " " 9.
" 20.9 " " " 14.

Add 252.1 for Spiral No. 5.
" 455.8 " " " 9.
" 712.4 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
79°	4723.1	7289.0	1695.9	**79°**
2′	4725.9	7291.6	1697.7	2′
4′	4728.7	7294.1	1699.5	4′
6′	4731.5	7296.7	1701.3	6′
8′	4734.3	7299.2	1703.0	8′
10′	4737.1	7301.8	1704.8	10′
12′	4739.9	7304.3	1706.6	12′
14′	4742.7	7306.9	1708.4	14′
16′	4745.5	7309.5	1710.2	16′
18′	4748.3	7312.0	1712.0	18′
20′	4751.2	7314.6	1713.7	20′
22′	4754.0	7317.2	1715.5	22′
24′	4756.9	7319.8	1717.3	24′
26′	4759.7	7322.3	1719.1	26′
28′	4762.5	7324.9	1720.9	28′
30′	4765.3	7327.4	1722.7	30′
32′	4768.2	7330.0	1724.5	32′
34′	4771.0	7332.5	1726.3	34′
36′	4773.8	7335.1	1728.1	36′
38′	4776.6	7337.6	1729.9	38′
40′	4779.4	9340.2	1731.7	40′
42′	4782.2	7342.8	1733.5	42′
44′	4785.1	7345.3	1735.3	44′
46′	4787.9	7347.9	1737.1	46′
48′	4790.7	7350.4	1738.9	48′
50′	4793.6	7353.0	1740.8	50′
52′	4796.4	7355.5	1742.6	52′
54′	4799.2	7358.1	1744.4	54′
56′	4802.0	7360.6	1746.2	56′
58′	4804.9	7363.2	1748.0	58′
80°	4807.7	7365.8	1749.9	**80°**
2′	4810.5	7368.4	1751.7	2′
4′	4813.3	7370.9	1573.5	4′
6′	4816.2	7373.5	1755.4	6′
8′	4819.0	7376.0	1757.2	8′
10′	4821.9	7378.5	1759.0	10′
12′	4824.7	7381.1	1760.8	12′
14′	4827.6	7383.6	1762.6	14′
16′	4830.4	7386.2	1764.5	16′
18′	4833.3	7388.7	1766.3	18′
20′	4836.2	7391.2	1768.2	20′
22′	4839.0	7393.8	1770.0	22′
24′	4841.9	7396.3	1771.9	24′
26′	4844.8	7398.9	1773.7	26′
28′	4847.6	7401.4	1775.6	28′

Add 252.1 for Spiral No. 5.
" 455.9 " " " 9.

Add 712.6 for Spiral No. 14.

Add 712.7 for Spiral No. 14.

Add 3.3 for Spiral No. 5.
" 9.4 " " " 9.
" 21.0 " " " 14.

Add 3.3 for Spiral No. 5.
" 9.5 " " " 9.
" 21.3 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
80° 30′	4850.5		7404.0	1777.4		**80°** 30′
32′	4853.4		7406.5	1779.3		32′
34′	4856.2		7409.1	1781.1		34′
36′	4859.1	Add 252.1 for Spiral No. 5. " 456.0 " " " 9. " 712.9 " " " 14.	7411.6	1783.0		36′
38′	4862.0		7414.2	1784.8		38′
40′	4864.8		7416.8	1786.7		40′
42′	4867.7		7419.3	1788.5		42′
44′	4870.6		6421.9	1790.4		44′
46′	4873.4		7424.4	1792.2		46′
48′	4876.3		7427.0	1794.1		48′
50′	4879.2		7429.5	1796.0	Add 21.4 for Spiral No. 14.	50′
52′	4882.0		7432.1	1797.9		52′
54′	4884.9		7434.6	1799.7		54′
56′	4887.8		7437.2	1801.6		56′
58′	4890.7		7439.7	1803.5		58′
81°	4893.6		7442.2	1805.4		**81°**
2′	4896.5		7444.7	1807.3		2′
4′	4899.3		7447.2	1809.1		4′
6′	4902.2		7449.8	1811.0		6′
8′	4905.1		7452.3	1812.9	Add 3.3 for Spiral No. 5. " 9.5 " " " 9.	8′
10′	4907.9		7454.8	1814.8		10′
12′	4910.8		7457.4	1816.7		12′
14′	4913.7		7459.9	1818.5		14′
16′	4916.6		7462.4	1820.4		16′
18′	4919.5		7464.9	1822.3		18′
20′	4922.4	Add 252.2 for Spiral No. 5. " 456.1 " " " 9. " 713.1 " " " 14.	7467.5	1824.2	Add 21.5 for Spiral No. 14.	20′
22′	4925.3		7470.0	1826.0		22′
24′	4928.2		7472.5	1827.9		24′
26′	4931.1		7475.1	1829.8		26′
28′	4934.0		7477.6	1831.7		28′
30′	4936.9		7480.1	1833.6		30′
32′	4939.8		7482.6	1835.5		32′
34′	4942.7		7485.1	1837.4		34′
36′	4945.6		7487.7	1839.3		36′
38′	4948.5		7490.2	1841.2		38′
40′	4951.4		7492.7	1843.1		40′
42′	4954.3		7495.2	1845.0		42′
44′	4957.2		7497.7	1846.9		44′
46′	4960.2		7500.2	1848.8		46′
48′	4963.1		7502.7	1850.7		48′
50′	4966.0		7505.3	1852.6		50′
52′	4968.9		7507.9	1854.5		52′
54′	4971.9		7510.4	1856.4		54′
56′	4974.8		7512.9	1858.3		56′
58′	4977.7		7515.4	1860.2		58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
82°	4980.6	7517.9	1862.2	**82°**
2′	4983.6	7520.4	1864.1	2′
4′	4986.5	7522.9	1866.0	4′
6′	4989.4	7525.4	1867.9	6′
8′	4992.4	7527.9	1869.8	8′
10′	4995.3	7530.4	1871.8	10′
12′	4998.3	7532.9	1873.7	12′
14′	5001.2	7535.4	1875.6	14′
16′	5004.2	7537.9	1877.6	16′
18′	5007.1	7540.4	1879.5	18′
20′	5010.0	7543.0	1881.5	20′
22′	5013.0	7545.5	1883.4	22′
24′	5015.9	7548.0	1885.3	24′
26′	5018.9	7550.5	1887.3	26′
28′	5021.8	7553.0	1889.2	28′
30′	5024.7	7555.5	1891.2	30′
32′	5027.7	7558.0	1893.1	32′
34′	5030.6	7560.5	1895.1	34′
36′	5033.6	7563.0	1897.0	36′
38′	5036.5	7565.5	1899.0	38′
40′	5039.5	7568.0	1900.9	40′
42′	5042.4	7570.5	1902.9	42′
44′	5045.4	7573.0	1904.8	44′
46′	5048.4	7575.5	1906.8	46′
48′	5051.3	7578.0	1908.7	48′
50′	5054.3	7580.6	1910.7	50′
52′	5057.3	7583.1	1912.6	52′
54′	5060.2	7585.6	1914.6	54′
56′	5063.2	7588.1	1916.5	56′
58′	5066.1	7590.6	1918.5	58′
83°	5069.1	7593.1	1920.5	**83°**
2′	5072.1	7595.6	1922.5	2′
4′	5075.1	7598.1	1924.4	4′
6′	5078.0	7600.5	1926.4	6′
8′	5081.0	7603.0	1928.4	8′
10′	5084.0	7605.5	1930.4	10′
12′	5087.0	7608.0	1932.4	12′
14′	5089.9	7610.5	1934.4	14′
16′	5092.9	7613.0	1936.3	16′
18′	5095.9	7615.5	1938.3	18′
20′	5098.9	7618.0	1940.3	20′
22′	5101.9	7620.5	1942.3	22′
24′	5104.9	7623.0	1944.3	24′
26′	5107.8	7625.5	1946.3	26′
28′	5110.8	7628.0	1948.3	28′

Add 252.2 for Spiral No. 5.
" 456.2 " " " 9.
" 713.4 " " " 14.

Add 21.6 for Spiral No. 14.

Add 3.4 for Spiral No. 5.
" 9.6 " " " 9.

Add 21.7 for Spiral No. 14.

Add 252.3 for Spiral No. 5.
" 456.3 " " " 9.
" 713.6 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
83° 30′	5113.8	7630.4	1950.3	**83°** 30′
32′	5116.8	7632.9	1952.3	32′
34′	5119.8	7635.4	1954.3	34′
36′	5122.8	7637.9	1956.3	36′
38′	5125.8	7640.4	1958.3	38′
40′	5128.8	7642.9	1960.3	40′
42′	5131.9	7645.4	1962.3	42′
44′	5134.9	7647.8	1964.3	44′
46′	5137.9	7650.3	1966.3	46′
48′	5140.9	7652.8	1968.3	48′
50′	5143.9	7655.3	1970.3	50′
52′	5146.9	7657.8	1972.3	52′
54′	5149.9	7660.3	1974.4	54′
56′	5152.9	7662.8	1976.4	56′
58′	5155.9	7665.3	1978.4	58′
84°	5158.9	7667.8	1980.4	**84°**
2′	5161.9	7670.2	1982.4	2′
4′	5165.0	7672.7	1984.5	4′
6′	5168.0	7675.2	1986.5	6′
8′	5171.0	7677.6	1988.5	8′
10′	5174.0	7680.1	1990.5	10′
12′	5177.1	7682.6	1992.5	12′
14′	5180.1	7685.1	1994.6	14′
16′	5183.1	7687.6	1996.6	16′
18′	5186.2	7690.0	1998.6	18′
20′	5189.2	7692.5	2000.7	20′
22′	5192.2	7695.0	2002.7	22′
24′	5195.3	7697.5	2004.7	24′
26′	5198.3	7699.9	2006.8	26′
28′	5201.4	7702.4	2008.8	28′
30′	5204.4	7704.8	2010.9	30′
32′	5207.4	7707.3	2012.9	32′
34′	5210.5	7709.8	2015.0	34′
36′	5213.5	7712.3	2017.0	36′
38′	5216.6	7714.8	2019.1	38′
40′	5219.6	7717.2	2021.1	40′
42′	5222.6	7719.7	2023.2	42′
44′	5225.7	7722.1	2025.2	44′
46′	5228.8	7724.6	2027.3	46′
48′	5231.9	7727.0	2029.3	48′
50′	5234.9	7729.5	2031.4	50′
52′	5238.0	7732.0	2033.4	52′
54′	5241.0	7734.4	2035.5	54′
56′	5244.1	7736.9	2037.6	56′
58′	5247.2	7739.3	2039.6	58′

Add 713.7 for Spiral No. 14.
Add 252.3 for Spiral No. 5.
" 456.4 " " 9.
Add 713.9 for Spiral No. 14.

Add 21.9 for Spiral No. 14.
Add 3.4 for Spiral No. 5.
" 9.7 " " 9.
Add 22.0 for Spiral No. 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
85°	5250.2 Add 714.1 for Spiral No. 14. Add 252.3 for Spiral No. 5. " 456.5 " " 9.	7741.8	2041.7 Add 22.1 for Spiral No. 14. Add 3.4 for Spiral No. 5. " 9.8 " " 9.	**85°**
2′	5253.3	7744.2	2043.7	2′
4′	5256.4	7746.7	2045.8	4′
6′	5259.5	7749.1	2047.9	6′
8′	5262.6	7751.6	2050.0	8′
10′	5265.6	7754.1	2052.1	10′
12′	5268.7	7756.5	2054.1	12′
14′	5271.8	7759.0	2056.2	14′
16′	5274.9	7761.4	2058.3	16′
18′	5278.0	7763.9	2060.4	18′
20′	5281.0	7766.4	2062.5	20′
22′	5284.1	7768.8	2064.6	22′
24′	5287.2	7771.3	2066.7	24′
26′	5290.3	7773.7	2068.8	26′
28′	5293.4	7776.1	2070.9	28′
30′	5296.4 Add 714.2 for Spiral No. 14.	7778.6	2073.0 Add 22.2 for Spiral No. 14.	30′
32′	5299.5	7781.0	2075.1	32′
34′	5302.6	7783.5	2077.2	34′
36′	5305.7	7785.9	2079.3	36′
38′	5308.8	7788.4	2081.4	38′
40′	5311.9	7790.8	2083.5	40′
42′	5315.0	7793.2	2085.6	42′
44′	5318.1	7795.7	2087.7	44′
46′	5321.2	7798.1	2089.9	46′
48′	5324.3	7800.6	2092.0	48′
50′	5327.4	7803.1	2094.1	50′
52′	5330.5	7805.5	2096.2	52′
54′	5333.6	7808.0	2098.3	54′
56′	5336.7	7810.4	2100.5	56′
58′	5339.8	7812.8	2102.6	58′
86°	5342.9 Add 252.4 for Spiral No. 5. " 456.6 " " " 9. " 714.4 " " " 14.	7815.3	2104.7 Add 3.5 for Spiral No. 5. " 9.8 " " " 9. " 22.3 " " " 14.	**86°**
2′	5346.0	7817.7	2106.8	2′
4′	5349.1	7820.2	2109.0	4′
6′	5352.2	7822.6	2111.2	6′
8′	5355.4	7825.0	2113.3	8′
10′	5358.5	7827.4	2115.4	10′
12′	5361.6	7829.8	2117.5	12′
14′	5364.8	7832.3	2119.7	14′
16′	5367.9	7834.7	2121.8	16′
18′	5371.0	7837.1	2124.0	18′
20′	5374.2	7839.5	2126.1	20′
22′	5377.3	7842.0	2128.2	22′
24′	5380.5	7844.4	2130.4	24′
26′	5383.6	7846.8	2132.5	26′
28′	5386.8	7849.2	2134.7	28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
86° 30′	5389.9	7851.6	2136.9	**86°** 30′
32′	5393.0	7854.0	2139.0	32′
34′	5396.2 Add 252.4 for Spiral No. 5. " 456.6 " " " 9. " 714.5 " " " 14.	7856.5	2141.2	34′
36′	5399.3	7858.9	2143.3	36′
38′	5402.5	7861.4	2145.5	38′
40′	5405.6	7863.8	2147.7	40′
42′	5408.8	7866.3	2149.8	42′
44′	5412.0	7868.7	2152.0	44′
46′	5415.2	7871.1	2154.1	46′
48′	5418.3	7873.5	2156.3	48′
50′	5421.4	7875.9	2158.5 Add 22.4 for Spiral No. 14	50′
52′	5424.6	7878.3	2160.6	52′
54′	5427.7	7880.8	2162.8	54′
56′	5430.8	7883.2	2165.0	56′
58′	5434.0	7885.6	2167.2	58′
87°	5437.2	7888.0	2169.4	**87°**
2′	5440.4	7890.4	2171.6	2′
4′	5443.5	7892.8	2173.8	4′
6′	5446.7	7895.2	2176.0	6′
8′	5449.9	7897.6	2178.1 Add 3.5 for Spiral No. 5. " 9.9 " " " 9.	8′
10′	5453.0	7900.0	2180.3	10′
12′	5456.1	7902.4	2182.5	12′
14′	5459.3	7904.8	2184.6	14′
16′	5462.5	7907.2	2186.8	16′
18′	5465.7	7909.7	2189.0	18′
20′	5468.9 Add 252.4 for Spiral No. 5. " 456.7 " " " 9. " 714.7 " " " 14.	7912.1	2191.2 Add 22.5 for Spiral No. 14.	20′
22′	5472.1	7914.5	2193.4	22′
24′	5475.3	7916.9	2195.6	24′
26′	5478.5	7919.3	2197.8	26′
28′	5481.7	7921.7	2200.0	28′
30′	5484.9	7924.1	2202.2	30′
32′	5488.1	7926.5	2204.4	32′
34′	5491.3	7928.9	2206.6	34′
36′	5494.5	7931.4	2208.8	36′
38′	5497.7	7933.8	2211.0	38′
40′	5500.9	7936.2	2213.3	40′
42′	5504.1	7938.6	2215.5	42′
44′	5507.3	7941.0	2217.7	44′
46′	5510.5	7943.4	2220.0	46′
48′	5513.7	7945.8	2222.2	48′
50′	5516.9	7948.2	2224.4	50′
52′	5520.2	7950.6	2226.6	52′
54′	5523.4	7953.0	2228.8	54′
56′	5526.6	7955.4	2231.1	56′
58′	5529.8	7957.8	2233.3	58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
88°	5533.0	7960.2	2235.5	**88°**
2′	5536.3	7962.6	2237.7	2′
4′	5539.5	7965.0	2239.9	4′
6′	5542.7	7967.4	2242.2	6′
8′	5545.9	7969.8	2244.4	8′
10′	5549.1	7972.2	2246.7	10′
12′	5552.4	7974.6	2248.9	12′
14′	5555.6	7977.0	2251.2	14′
16′	5558.9	7979.4	2253.4	16′
18′	5562.1	7981.8	2255.7	18′
20′	5565.3	7984.1	2258.0	20′
22′	5568.6	7986.5	2260.2	22′
24′	5571.8	7988.9	2262.5	24′
26′	5575.1	7991.3	2264.7	26′
28′	5578.3	7993.7	2267.0	28′
30′	5581.5	7996.1	2269.3	30′
32′	5584.8	7998.5	2271.7	32′
34′	5588.0	8000.9	2273.8	34′
36′	5591.3	8003.3	2276.1	36′
38′	5594.5	8005.7	2278.4	38′
40′	5597.8	8008.0	2280.7	40′
42′	5601.1	8010.4	2283.0	42′
44′	5604.3	8012.8	2285.2	44′
46′	5607.6	8015.2	2287.5	46′
48′	5610.8	8017.5	2289.8	48′
50′	5614.1	8019.9	2292.1	50′
52′	5617.4	8022.3	2294.4	52′
54′	5620.6	8024.7	2296.7	54′
56′	5623.9	8027.1	2299.0	56′
58′	5627.1	8029.5	2301.2	58′
89°	5630.4	8031.8	2303.5	**89°**
2′	5633.7	8034.2	2305.8	2′
4′	5636.9	8036.6	2308.1	4′
6′	5640.2	8038.9	2310.4	6′
8′	5643.5	8041.3	2312.7	8′
10′	5646.8	8043.6	2315.0	10′
12′	5650.1	8046.0	2317.3	12′
14′	5653.4	8048.3	2319.6	14′
16′	5656.7	8050.7	2321.9	16′
18′	5660.0	8053.1	2323.2	18′
20′	5663.3	8055.5	2326.6	20′
22′	5666.6	8057.8	2328.9	22′
24′	5669.9	8060.2	2331.2	24′
26′	5673.2	8062.5	2333.5	26′
28′	5676.5	8064.9	2335.8	28′

Add 714.9 for Spiral No. 14.

Add 252.5 for Spiral No. 5.
" 456.8 " " 9.

Add 715.0 for Spiral No. 14.

Add 22.6 for Spiral No. 14.

Add 3.5 for Spiral No. 5.
" 10.0 " " 9.

Add 22.7 for Spiral No. 14.

Add 3.6 for Spiral No. 5.
" 10.1 " " 9.
" 22.8 " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
89° 30′	5679.8	8067.3	2338.2	**89°** 30′
32′	5683.1	8069.6	2340.5	32′
34′	5686.4	8072.0	2342.8	34′
36′	5689.8	8074.4	2345.1	36′
38′	5693.1	8076.8	2347.4	38′
40′	5696.4	8079.2	2349.8	40′
42′	5699.8	8081.6	2352.1	42′
44′	5703.1	8083.9	2354.4	44′
46′	5706.4	8086.3	2356.8	46′
48′	5709.7	8088.7	2359.1	48′
50′	5713.0	8091.0	2361.5	50′
52′	5716.4	8093.4	2363.8	52′
54′	5719.7	8095.7	2366.2	54′
56′	5723.0	8098.1	2368.5	56′
58′	5726.3	8100.5	2370.9	58′
90°	5729.6	8102.9	2373.3	**90°**
2′	5732.9	8105.2	2375.7	2′
4′	5736.3	8107.6	2378.1	4′
6′	5739.6	8109.9	2380.4	6′
8′	5743.0	8112.3	2382.8	8′
10′	5746.3	8114.6	2385.1	10′
12′	5749.7	8117.0	2387.5	12′
14′	5753.0	8119.3	2389.8	14′
16′	5756.4	8121.7	2392.2	16′
18′	5759.7	8124.0	2394.6	18′
20′	5763.0	8126.4	2397.0	20′
22′	5766.4	8128.7	2399.4	22′
24′	5769.7	8131.1	2401.8	24′
26′	5773.0	8133.4	2404.1	26′
28′	5776.4	8135.8	2406.5	28′
30′	5779.8	8138.1	2408.9	30′
32′	5783.1	8140.5	2411.3	32′
34′	5786.5	8142.8	2413.7	34′
36′	5789.8	8145.2	2416.1	36′
38′	5793.2	8147.5	2418.5	38′
40′	5796.6	8149.8	2420.9	40′
42′	5800.0	8152.2	2423.3	42′
44′	5803.3	8154.5	2425.7	44′
46′	5806.7	8156.9	2428.1	46′
48′	5810.1	8159.2	2430.5	48′
50′	5813.5	8161.6	2432.9	50′
52′	5816.9	8163.9	2435.3	52′
54′	5820.3	8166.2	2437.7	54′
56′	5823.7	8168.6	2440.1	56′
58′	5827.0	8170.9	2442.5	58′

Add 252.5 for Spiral No. 5.
" 457.0 " " 9.
" 715.2 " " 14.

Add 3.6 for Spiral No. 5.
" 10.1 " " 9.
" 22.9 " " 14.

Add 715.5 for Spiral No. 14.

Add 73.0 for Spiral No. 14.

Add 252.6 for Spiral No. 5.
" 457.1 " " 9.

Add 3.6 for Spiral No. 5.
" 10.2 " " 9.

Add 715.6 for Spiral No. 14.

Add 23.1 for Spiral No. 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
91°	5830.4	8173.3	2445.0	**91°**
2′	5833.8	8175.6	2447.4	2′
4′	5837.2	8178.0	2449.8	4′
6′	5840.6	8180.3	2452.3	6′
8′	5844.0	8182.6	2454.7	8′
10′	5847.4	8184.9	2457.1	10′
12′	5850.8	8187.2	2459.5	12′
14′	5854.2	8189.6	2462.0	14′
16′	5857.6	8191.9	2464.4	16′
18′	5861.0	8194.3	2466.8	18′
20′	5864.5	8196.6	2469.3	20′
22′	5867.9	8199.0	2471.7	22′
24′	5871.3	8201.3	2474.2	24′
26′	5874.8	8203.6	2476.6	26′
28′	5878.2	8205.9	2479.1	28′
30′	5881.6	8208.2	2481.5	30′
32′	5885.0	8210.6	2484.0	32′
34′	5888.5	8212.9	2486.4	34′
36′	5892.0	8215.2	2488.9	36′
38′	5895.4	8217.5	2491.3	38′
40′	5898.8	8219.8	2493.8	40′
42′	5902.3	8222.1	2496.2	42′
44′	5905.7	8224.5	2498.7	44′
46′	5909.2	8226.8	2501.1	46′
48′	5912.6	8229.1	2503.6	48′
50′	5916.0	8231.4	2506.1	50′
52′	5919.5	8233.8	2508.6	52′
54′	5922.9	8236.1	2511.0	54′
56′	5926.4	8238.4	2513.5	56′
58′	5929.8	8240.7	2516.0	58′
92°	5933.2	8243.0	2518.5	**92°**
2′	5936.7	8245.3	2521.0	2′
4′	5940.1	8247.7	2523.5	4′
6′	5943.6	8250.0	2526.0	6′
8′	5947.0	8252.3	2528.5	8′
10′	5950.5	8254.6	2531.0	10′
12′	5954.0	8256.9	2533.5	12′
14′	5957.4	8259.2	2536.0	14′
16′	5960.9	8261.5	2538.5	16′
18′	5964.3	8263.8	2541.0	18′
20′	5967.8	8266.1	2543.5	20′
22′	5971.3	8268.4	2546.0	22′
24′	5974.8	8270.8	2548.5	24′
26′	5978.2	8273.1	2551.1	26′
28′	5981.7	8275.4	2553.6	28′

Add 252.6 for Spiral No. 5.
" 457.2 " " 9.
" 715.8 " " 14.

Add 23.2 for Spiral No. 14.

Add 3.6 for Spiral No. 5.
" 10.3 " " 9.

Add 23.3 for Spiral No. 14.

Add 252.7 for Spiral No. 5.
" 457.3 " " 9.
" 716.0 " " 14.

Add 3.7 for Spiral No. 5.
" 10.4 " " 9.
" 23.4 " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
92° 30′	5985.2	8277.7	2556.1	92° 30′
32′	5988.7	8280.0	2558.6	32′
34′	5992.2	8282.3	2561.1	34′
36′	5995.7 Add 252.7 for Spiral No. 5. " 457.3 " " 9. " 716.1 " " 14.	8284.6	2563.7	36′
38′	5999.1	8286.9	2566.2	38′
40′	6002.6	8289.2	2568.7	40′
42′	6006.1	8291.5	2571.2	42′
44′	6009.6	8293.8	2573.8	44′
46′	6013.1	8296.1	2576.3	46′
48′	6016.6	8298.4	2578.9	48′
50′	6020.1	8300.7	2581.4	50′
52′	6023.6	8303.0	2584.0 Add 23.6 for Spiral No. 14.	52′
54′	6027.1	8305.3	2586.5	54′
56′	6030.6	8307.6	2589.1	56′
58′	6034.1	8309.9	2591.6	58′
93°	6037.7	8312.2	2594.1	93°
2′	6041.2	8314.5	2596.7	2′
4′	6044.7	8316.8	2599.2	4′
6′	6048.3	8319.1	2601.8 Add 3.7 for Spiral No. 5. " 10.5 " " 9.	6′
8′	6051.8	8321.4	2604.4	8′
10′	6055.3	8323.7	2606.9	10′
12′	6058.9	8326.0	2609.5	12′
14′	6052.4	8328.3	2612.0	14′
16′	6056.0	8330.6	2614.6	16′
18′	6059.5	8332.9	2617.2 Add 23.7 for Spiral No. 14.	18′
20′	6073.0 Add 252.7 for Spiral No. 5. " 457.4 " " 0. " 716.4 " " 14.	8335.1	2619.8	20′
22′	6076.6	8337.4	2622.4	22′
24′	6080.1	8339.7	2625.0	24′
26′	6083.7	8342.0	2627.5	26′
28′	6087.2	8344.2	2630.1	28′
30′	6090.7	8346.5	2632.7	30′
32′	6094.3	8348.8	2635.3	32′
34′	6097.8	8351.1	2637.9	34′
36′	6101.4	8353.3	2640.4	36′
38′	6104.9	8355.6	2643.0	38′
40′	6108.5	8357.9	2645.6	40′
42′	6112.0	8360.2	2648.2	42′
44′	6115.6	8362.4	2650.8	44′
46′	6119.2	8364.7	2653.4	46′
48′	6122.7	8367.0	2656.0	48′
50′	6126.3	8369.3	2658.6	50′
52′	6129.9	8371.6	2661.2	52′
54′	6133.4	8373.8	2663.8	54′
56′	6137.0	8376.1	2666.4	56′
58′	6140.6	8378.4	2669.0	58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
94°	6144.2	8380.7	2671.6	**94°**
2′	6147.8	8383.0	2674.2	2′
4′	6151.4	8385.2	2676.8	4′
6′	6155.0	8387.5	2679.5	6′
8′	6158.6	8389.8	2682.1	8′
10′	6162.1	8392.1	2684.7	10′
12′	6165.7	8394.3	2687.3	12′
14′	6169.3	8396.6	2690.0	14′
16′	6172.9	8398.9	2692.6	16′
18′	6176.5	8401.1	2695.3	18′
20′	6180.1	8403.4	2697.9	20′
22′	6183.8	8405.7	2700.6	22′
24′	6187.4	8408.0	2703.2	24′
26′	6191.0	8410.2	2705.9	26′
28′	6194.6	8412.5	2708.5	28′
30′	6198.2	8414.7	2711.2	30′
32′	6201.9	8417.0	2713.9	32′
34′	6205.5	8419.3	2716.5	34′
36′	6209.1	8421.5	2719.2	36′
38′	6212.7	8423.8	2721.8	38′
40′	6216.3	8426.0	2724.5	40′
42′	6220.0	8428.3	2727.2	42′
44′	6223.6	8430.5	2729.8	44′
46′	6227.3	8432.8	2732.5	46′
48′	6230.9	8435.0	2735.2	48′
50′	6234.5	8437.3	2737.9	50′
52′	6238.2	8439.5	2740.6	52′
54′	6241.8	8441.8	2743.3	54′
56′	6245.5	8444.0	2746.0	56′
58′	6249.1	8446.3	2748.6	58′
95°	6252.7	8448.6	2751.3	**95°**
2′	6256.4	8450.9	2754.0	2′
4′	6260.0	8453.1	2756.7	4′
6′	6263.7	8455.4	2759.4	6′
8′	6267.3	8457.6	2762.1	8′
10′	6271.0	8459.8	2764.8	10′
12′	6274.7	8462.1	2767.5	12′
14′	6278.3	8464.3	2770.2	14′
16′	6282.0	8466.6	2772.9	16′
18′	6285.7	8468.8	2775.6	18′
20′	6289.4	8471.1	2778.3	20′
22′	6293.1	8473.3	2781.0	22′
24′	6296.7	8475.6	2783.7	24′
26′	6300.4	8477.8	2786.5	26′
28′	6304.1	8480.1	2789.2	28′

Add 252.7 for Spiral No. 5.
" 457.6 " " 9.
" 716.8 " " 14.

Add 717.0 for Spiral No. 14.

Add 252.8 for Spiral No. 5.
" 457.7 " " 9.
Add 717.2 for Spiral No. 14.

Add 23.9 for Spiral No. 14.

Add 3.7 for Spiral No. 5.
" 10.6 " " 9.
Add 24.0 for Spiral No. 14.

Add 3.8 for Spiral No. 5.
" 10.7 " " 9.
Add 24.1 for Spiral No. 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
5° 30′	6307.8	Add 252.8 for Spiral No. 5. " 457.8 " " 9. " 717.2 " " 14.	8482.3	2791.9	Add 3.8 for Spiral No. 5. " 10.7 " " 9. " 24.2 " " 14.	**95°** 30′
32′	6311.5		8484.6	2794.6		32′
34′	6315.2		8486.8	2797.4		34′
36′	6318.9		8489.1	2800.1		36′
38′	6322.6		8491.3	2802.9		38′
40′	6326.3		8493.5	2805.6		40′
42′	6330.0		8495.8	2808.3		42′
44′	6333.7		8498.0	2811.1		44′
46′	6337.4		8500.2	2813.9		46′
48′	6341.1		8502.4	2816.6		48′
50′	6344.8		8504.6	2819.4		50′
52′	6348.5		8506.8	2822.2		52′
54′	6352.2		8509.0	2825.0		54′
56′	6356.0		8511.3	2827.7		56′
58′	6359.7		8513.5	2830.5		58′
6°	6363.4	Add 457.9 for Spiral No. 9. Add 717.4 for Spiral No. 14.	8515.8	2833.2		**96°**
2′	6367.1		8518.0	2836.0		2′
4′	6370.8		8520.3	2838.7		4′
6′	6374.6		8522.5	2841.5		6′
8′	6378.3		8524.8	2844.3		8′
10′	6382.0		8527.0	2847.1		10′
12′	6385.7		8529.3	2849.9		12′
14′	6389.5		8531.5	2852.7		14′
16′	6393.2		8533.7	2855.4		16′
18′	6397.0		8535.9	2858.2		18′
20′	6400.7	Add 252.8 for Spiral No. 5.	8538.1	2861.0	Add 3.8 for Spiral No. 5. " 10.8 " " 9. " 24.3 " " 14.	20′
22′	6404.5		8540.3	2863.8		22′
24′	6408.3		8542.5	2866.6		24′
26′	6412.0		8544.8	2869.4		26′
28′	6415.8		8547.0	2872.2		28′
30′	6419.5		8549.2	2875.0		30′
32′	6423.3		8551.4	2877.8		32′
34′	6427.0		8553.6	2880.6		34′
36′	6430.8		8555.9	2883.4		36′
38′	6434.6		8558.1	2886.2		38′
40′	6438.3	Add 458.0 for Spiral No. 9. Add 717.5 for Spiral No. 14.	8560.3	2889.0		40′
42′	6442.1		8562.5	2891.8		42′
44′	6445.8		8564.7	2894.6		44′
46′	6449.6		8567.0	2897.4		46′
48′	6453.4		8569.2	2900.2		48′
50′	6457.2		8571.4	2903.1		50′
52′	6461.0		8573.6	2905.9		52′
54′	6464.8		8575.8	2908.7		54′
56′	6468.6		8578.0	2911.6		56′
58′	6472.4		8580.2	2914.4		58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
97°	6476.1		8582.4	2917.3		**97°**
2′	6479.9		8584.6	2920.2		2′
4′	6483.7		8586.8	2923.0		4′
6′	6487.5	Add 717.7 for Spiral No. 14.	8589.0	2925.9		6′
8′	6491.3		8591.2	2928.7	Add 24.5 for Spiral No. 14.	8′
10′	6495.1		8593.5	2931.6		10′
12′	6498.9		8595.7	2934.5		12′
14′	6502.7		8597.9	2937.3		14′
16′	6506.5		8600.1	2940.2		16′
18′	6510.4		8602.3	2943.0		18′
20′	6514.2	Add 252.9 for Spiral No. 5. " 458.1 " " 9.	8604.5	2945.9		20′
22′	6518.0		8606.7	2948.8	Add 3.8 for Spiral No. 5. " 10.9 " " 9.	22′
24′	6521.9		8608.9	2951.7		24′
26′	6525.7		8611.1	2954.5		26′
28′	6529.5		8613.3	2957.4		28′
30′	6533.3		8615.5	2960.3		30′
32′	6537.2		8617.7	2963.2		32′
34′	6541.0	Add 717.8 for Spiral No. 14.	8619.9	2966.1	Add 24.6 for Spiral No. 14.	34′
36′	6544.8		8622.1	2968.9		36′
38′	6548.7		8624.3	2971.8		38′
40′	6552.5		8626.5	2974.7		40′
42′	6556.4		8628.7	2977.6		42′
44′	6560.2		8630.8	2980.5		44′
46′	6564.0		8633.0	2983.4		46′
48′	6567.9		8635.2	2986.3		48′
50′	6571.8		8637.4	2989.2		50′
52′	6575.7		8639.6	2992.1		52′
54′	6579.5		8641.8	2995.0		54′
56′	6583.4		8644.0	2997.9		56′
58′	6587.2		8646.2	3000.8		58′
98°	6591.1		8648.4	3003.8		**98°**
2′	6595.0	Add 252.9 for Spiral No. 5. " 458.2 " " 9. " 718.0 " " 14.	8650.6	3006.7	Add 3.9 for Spiral No. 5. " 11.0 " " 9. " 24.7 " " 14.	2′
4′	6598.8		8652.8	3009.6		4′
6′	6602.7		8655.0	3012.5		6′
8′	6606.6		8657.2	3015.5		8′
10′	6610.5		8659.3	3018.4		10′
12′	6614.4		8661.5	3021.3		12′
14′	6618.3		8663.7	3024.2		14′
16′	6622.2		8665.8	3027.2		16′
18′	6626.1		8668.0	3030.1		18′
20′	6630.0		8670.2	3033.1		20′
22′	6633.9		8672.4	3036.0		22′
24′	6637.8		8674.5	3039.0		24′
26′	6641.7		8676.7	3042.0		26′
28′	6645.6		8678.9	3044.9		28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
8° 30′	6649.5	8681.1	3047.9	**98°** 30′
32′	6653.5	8683.3	3050.9	32′
34′	6657.4	8685.5	3053.9	34′
36′	6661.3 Add 252.9 for Spiral No. 5. " 458.3 " " 9. " 718.1 " " 14.	8687.6	3056.8 Add 3.9 for Spiral No. 5. " 11.0 " " 9. " 24.8 " " 14.	36′
38′	6665.2	8689.8	3059.8	38′
40′	6669.1	8692.0	3062.8	40′
42′	6673.1	8694.2	3065.8	42′
44′	6677.0	8696.3	3068.8	44′
46′	6681.0	8698.5	3071.8	46′
48′	6684.9	8700.7	3074.7	48′
50′	6688.8	8702.9	3077.7	50′
52′	6692.8	8705.0	3080.7	52′
54′	6696.7	8707.2	3083.7	54′
56′	6700.6	8709.3	3086.7	56′
58′	6704.6	8711.5	3089.7	58′
9°	6708.5	8713.7	3092.7	**99°**
2′	6712.5	8715.9	3095.7	2′
4′	6716.5	8718.0	3098.7	4′
6′	6720.4 Add 718.3 for Spiral No. 14.	8720.2	3101.7	6′
8′	6724.4	8722.3	3104.8 Add 25.0 for Spiral No. 14.	8′
10′	6728.3	8724.5	3107.8	10′
12′	6732.3	8726.6	3110.8	12′
14′	6736.3	8728.8	3113.8	14′
16′	6740.2	8730.9	3116.9	16′
18′	6744.2	8733.1	3119.9	18′
20′	6748.1 Add 253.0 for Spiral No. 5. " 458.4 " " 9.	8735.3	3122.9 Add 3.9 for Spiral No. 5. " 11.1 " " 9.	20′
22′	6752.1	8737.4	3126.0	22′
24′	6756.1	8739.6	3129.0	24′
26′	6760.1	8741.7	3132.0	26′
28′	6764.0	8743.9	3135.1	28′
30′	6768.0	8746.0	3138.1	30′
32′	6772.0 Add 718.4 for Spiral No. 14.	8748.2	3141.1 Add 25.1 for Spiral No. 14.	32′
34′	6776.0	8750.3	3144.2	34′
36′	6780.0	8752.5	3147.2	36′
38′	6784.0	8754.7	3150.3	38′
40′	6788.0	8756.8	3153.4	40′
42′	6792.0	8759.0	3156.4	42′
44′	6796.1	8761.1	3159.5	44′
46′	6800.1	8763.3	3162.6	46′
48′	6804.1	8765.4	3165.6	48′
50′	6808.1	8767.5	3168.7	50′
52′	6812.1	8769.7	3171.8	52′
54′	6816.1	8771.8	3174.8	54′
56′	6820.2	8774.0	3177.9	56′
58′	6824.2	8776.1	3181.0	58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
01° 30′	7012.7	8873.9	3326.2	**101°** 30′
32′	7016.9	8876.0	3329.4	32′
34′	7021.0	8878.1	3332.7	34′
36′	7025.2	8880.3	3335.9	36′
38′	7029.4	8882.4	3339.2	38′
40′	7033.6	8884.5	3342.4	40′
42′	7037.8	8886.6	3345.6	42′
44′	7042.0	8888.7	3348.9	44′
46′	7046.1	8890.8	3352.1	46′
48′	7050.3	8892.9	3355.4	48′
50′	7054.5	8895.0	3358.6	50′
52′	7058.7	8897.1	3361.8	52′
54′	7062.9	8899.2	3365.1	54′
56′	7067.1	8901.3	3368.3	56′
58′	7071.3	8903.4	3371.6	58′
02°	7075.5	8905.5	3374.9	**102°**
2′	7079.8	8907.6	3378.2	2′
4′	7084.0	8909.7	3381.5	4′
6′	7088.2	8911.8	3384.7	6′
8′	7092.4	8913.9	3388.0	8′
10′	7096.6	8916.0	3391.3	10′
12′	7100.9	8918.1	3394.6	12′
14′	7105.1	8920.2	3397.9	14′
16′	7109.3	8922.3	3401.2	16′
18′	7113.5	8924.4	3404.5	18′
20′	7117.7	8926.4	3407.8	20′
22′	7122.0	8928.5	3411.1	22′
24′	7126.2	8930.6	3414.4	24′
26′	7130.4	8932.7	3417.7	26′
28′	7134.7	8934.8	3421.0	28′
30′	7138.9	8936.9	3424.3	30′
32′	7143.2	8939.0	3427.6	32′
34′	7147.4	8941.1	3431.0	34′
36′	7151.7	8943.2	3434.3	36′
38′	7156.0	8945.3	3437.6	38′
40′	7160.2	8947.3	3440.9	40′
42′	7164.5	8949.4	3444.2	42′
44′	7168.7	8951.5	3447.6	44′
46′	7173.0	8953.6	3450.9	46′
48′	7177.3	8955.7	3454.2	48′
50′	7181.6	8957.7	3457.6	50′
52′	7185.9	8959.8	3460.9	52′
54′	7190.2	8961.8	3464.3	54′
56′	7194.5	8963.9	3467.6	56′
58′	7198.8	8966.0	3471.0	58′

Add 253.1 for Spiral No. 5.
" 458.8 " " " 9.
" 719.2 " " " 14.

Add 4.0 for Spiral No. 5.
" 11.4 " " " 9.
" 25.7 " " " 14.

Add 253.1 for Spiral No. 5.
" 458.9 " " " 9.
" 719.4 " " " 14.

Add 4.0 for Spiral No. 5.
" 11.5 " " " 9.
" 25.9 " " " 14.

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
103°	7203.1	Add 459.0 for Spiral No. 9. " 719.7 " " 14.	8968.1	3474.4	Add 4.1 for Spiral No. 5. " 11.6 " " 9. Add 26.2 for Spiral No. 14.	**103°**
2′	7207.4		8970.2	3477.8		2′
4′	7211.7		8972.2	3481.2		4′
6′	7216.0		8974.3	3484.5		6′
8′	7220.3		8976.4	3487.9		8′
10′	7224.6		8978.4	3491.3		10′
12′	7229.0		8980.5	3494.7		12′
14′	7233.3		8982.5	3498.1		14′
16′	7237.6		8984.6	3501.5		16′
18′	7241.9		8986.7	3504.9		18′
20′	7246.2		8988.7	3508.3		20′
22′	7250.6		8990.8	3511.7		22′
24′	7254.9		8992.8	3515.1		24′
26′	7259.2		8994.9	3518.5		26′
28′	7263.6		8997.0	3521.9		28′
30′	7267.9	Add 253.2 for Spiral No. 5. " 459.1 " " 9. " 719.9 " " 14.	8999.0	3525.3	Add 26.3 for Spiral No. 14.	30′
32′	7272.3		9001.1	3528.7		32′
34′	7276.6		9003.2	3532.2		34′
36′	7281.0		9005.2	3535.6		36′
38′	7285.3		9007.3	3539.0		38′
40′	7289.7		9009.3	3542.5		40′
42′	7294.0		9011.4	3545.9		42′
44′	7298.4		9013.4	3549.4		44′
46′	7302.8		9015.5	3552.8		46′
48′	7307.2		9017.5	3556.3		48′
50′	7311.6		9019.6	3559.7		50′
52′	7316.0		9021.6	3563.1		52′
54′	7320.4		9023.7	3566.6		54′
56′	7324.8		9025.7	3570.0		56′
58′	7329.2		9027.8	3573.5		58′
104°	7333.5	Add 459.2 for Spiral No. 9. " 720.1 " " 14.	9029.9	3577.0	Add 4.1 for Spiral No. 5. " 11.7 " " 9. " 26.5 " " 14.	**104°**
2′	7337.9		9031.9	3580.5		2′
4′	7342.3		9034.0	3583.9		4′
6′	7346.7		9036.0	3587.4		6′
8′	7351.1		9038.1	3590.9		8′
10′	7355.5		9040.2	3594.3		10′
12′	7360.0		9042.2	3597.8		12′
14′	7364.4		9044.3	3601.2		14′
16′	7368.8		9046.3	3604.7		16′
18′	7373.2		9048.4	3608.2		18′
20′	7377.6		9050.4	3611.7		20′
22′	7382.1		9052.5	3615.2		22′
24′	7386.5		9054.5	3618.7		24′
26′	7390.9		9056.6	3622.2		26′
28′	7395.4		9058.6	3625.7		28′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.	Long Chord.	External Secant.	Whole Angle.
104° 30′	7399.8	9060.6	3629.2	**104°** 30′
32′	7404.3	9062.7	3632.7	32′
34′	7408.8	9064.7	3636.2	34′
36′	7413.2	9066.8	3639.7	36′
38′	7417.7 Add 253.2 for Spiral No. 5. " 459.3 " " " 9. " 720.2 " " " 14.	9068.8	3643.3 Add 4.1 for Spiral No. 5. " 11.7 " " " 9. " 26.5 " " " 14.	38′
40′	7422.1	9070.8	3646.8	40′
42′	7426.6	9072.9	3650.3	42′
44′	7431.0	9074.9	3653.9	44′
46′	7435.5	9076.9	3657.4	46′
48′	7440.0	9079.0	3661.0	48′
50′	7444.5	9081.0	3664.5	50′
52′	7449.0	9083.0	3668.1	52′
54′	7453.5	9085.1	3671.6	54′
56′	7458.0	9087.1	3675.2	56′
58′	7462.5	9089.1	3678.8	58′
105°	7467.0	9091.1	3682.3	**105°**
2′	7471.5	9093.2	3685.8	2′
4′	7476.0	9095.2	3689.4	4′
6′	7480.5	9097.2	3693.0	6′
8′	7485.0	9099.3	3696.6	8′
10′	7489.5	9101.3	3700.2	10′
12′	7494.0	9103.3	3703.8	12′
14′	7498.6	9105.3	3707.4	14′
16′	7503.1	9107.4	3711.0	16′
18′	7507.6	9109.4	3714.6	18′
20′	7512.1 Add 253.3 for Spiral No. 5. " 459.4 " " " 9. " 720.5 " " " 14.	9111.4	3718.2 Add 4.2 for Spiral No. 5. " 11.8 " " " 9. " 26.8 " " " 14.	20′
22′	7516.7	9113.4	3721.8	22′
24′	7521.2	9115.5	3725.5	24′
26′	7525.8	9117.5	3729.1	26′
28′	7530.3	9119.5	3732.7	28′
30′	7534.8	9121.5	3736.3	30′
32′	7539.4	9123.5	3739.9	32′
34′	7543.9	9125.6	3743.6	34′
36′	7548.5	9127.6	3747.2	36′
38′	7553.0	9129.6	3750.8	38′
40′	7557.6	9131.6	3754.5	40′
42′	7562.1	9133.6	3758.2	42′
44′	7566.7	9135.6	3761.8	44′
46′	7571.3	9137.6	3765.5	46′
48′	7575.9	9139.6	3769.1	48′
50′	7580.5	9141.6	3772.7	50′
52′	7585.1	9143.6	3776.4	52′
54′	7589.7	9145.7	3780.0	54′
56′	7594.3	9147.7	3783.7	56′
58′	7598.9	9149.7	3787.4	58′

IX.—FUNCTIONS OF A ONE-DEGREE CURVE.

Whole Angle.	Tangent Distance.		Long Chord.	External Secant.		Whole Angle.
106°	7603.5		9151.7	3791.0		**106°**
2′	7608.1		9153.7	3794.7		2′
4′	7612.7		9155.7	3798.4		4′
6′	7617.3	Add 459.5 for Spiral No. 9. " 720.8 " " 14.	9157.7	3802.0		6′
8′	7621.9		9159.7	3805.7		8′
10′	7626.5		9161.7	3809.4		10′
12′	7631.1		9163.7	3813.1		12′
14′	7635.7		9165.7	3816.8		14′
16′	7640.4		9167.7	3820.5	Add 4.2 for Spiral No. 5. " 12.0 " " 9. " 27.1 " " 14.	16′
18′	7645.1		9169.7	3824.2		18′
20′	7649.7	Add 253.4 for Spiral No. 5.	9171.7	3827.9		20′
22′	7654.4		9173.7	3831.6		22′
24′	7659.0		9175.7	3835.4		24′
26′	7663.7		9177.7	3839.1		26′
28′	7668.3		9179.7	3842.8		28′
30′	7672.9		9181.7	3846.5		30′
32′	7677.6	Add 459.6 for Spiral No. 9. " 721.0 " " 14.	9183.7	3850.2		32′
34′	7682.2		9185.7	3854.0		34′
36′	7686.9		9187.7	3857.7		36′
38′	7691.5		9189.7	3861.5		38′
40′	7696.2		9191.7	3865.2		40′
42′	7700.9		9193.7	3869.0		42′
44′	7705.5		9195.7	3872.7		44′
46′	7710.2		9197.7	3876.5		46′
48′	7714.9		9199.7	3880.2		48′
50′	7719.6		9201.6	3884.0		50′
52′	7724.3		9203.6	3887.8		52′
54′	7729.0		9205.6	3891.6		54′
56′	7733.7		9207.6	3895.4	Add 4.3 for Spiral No. 5. " 12.2 " " 9. " 27.5 " " 14.	56′
58′	7738.4		9209.6	3899.1		58′
107°	7743.1		9211.5	3902.9		**107°**
2′	7747.9	Add 253.4 for Spiral No. 5. " 459.7 " " 9. " 721.2 " " 14.	9213.5	3906.7		2′
4′	7752.6		9215.5	3910.5		4′
6′	7757.3		9217.5	3914.3		6′
8′	7762.0		9219.4	3918.1		8′
10′	7766.7		9221.4	3921.9		10′
12′	7771.4		9223.4	3925.7		12′
14′	7776.2		9225.4	3929.5		14′
16′	7780.9		9227.3	3933.3		16′
18′	7785.7		9239.3	3937.1		18′
20′	7790.4		9231.3	3941.0		20′
22′	7795.2		9233.3	3944.8		22′
24′	7800.0		9235.3	3948.7		24′
26′	7804.7		9237.2	3952.5		26′
28′	7809.5		9239.2	3956.4		28′